WORKING PAPERS
DEPARTMENT OF ECONOMICS
WASHINGTON UNIVERSITY
ST. LOUIS, MISSOURI

NSG-342

URBAN EMPLOYMENT MULTIPLIERS AND THEIR APPLICATION TO THE AEROSPACE INDUSTRY IN ST. LOUIS

by Se-Hark Park

WASHINGTON UNIVERSITY

Department of Economics

Dissertation Committee:

Edward Greenberg, Chairman
Werner Hochwald
Murray L. Weidenbaum

AN ANALYSIS OF REGRESSION ESTIMATORS FOR URBAN EMPLOYMENT MULTIPLIERS AND THEIR APPLICATION TO THE EMPLOYMENT IMPACT OF THE AEROSPACE INDUSTRY IN THE ST. LOUIS STANDARD METROPOLITAN STATISTICAL AREA

by

Se-Hark Park

A dissertation presented to the
Graduate School of Arts and Sciences
of Washington University in
partial fulfilment of the
requirements for the degree
of Doctor of Philosophy

4 June, 1965

Saint Louis, Missouri

ACKNOWLEDGMENTS

Acknowledgment should be made for the valuable direction of Professor Edward Greenberg without whom the completion of this study would have been difficult. For helpful comments and suggestions, deep gratitude is expressed to Professors Werner Hochwald and Murray L. Weidenbaum, who have served on the thesis committee. I am greatly indebted also to Mr. Robert Landy for generous help in implementing the programming part of this study. Special thanks go to Mr. Raymond W. McCann and Mrs. Mildred Helmholt at the Missouri Division of Employment and Security, St. Louis, Mo., for providing the basic employment data needed for the statistical estimation of the model developed in this study. Finally, I am grateful to Washington University and The National Aeronautics and Space Administration (Research Grant NsG-342) for the financial support extended to aid in the completion of this study.

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CHAPTER I

INTRODUCTION

A. A Brief Survey of the Literature

The idea that a change in effective demand can initiate a series of cumulative effects has been conceived for a long time by a great number of outstanding economists such as W. Bagehot, N. Johanssen, J. Warming, A. C. Pigou and A. Schowner.[1] However, it was the famous R. F. Kahn article in 1931 that formally stated the idea of the multiplier effects in a simple form.[2] Kahn's multiplier was an employment multiplier, which concerns the effects of public works, and of any net increase in the rate of investment expenditure, on unemployment. Later, Keynes developed an income multiplier and used it extensively as analytical tool for the study of national income and employment. Subsequently, the application of the multiplier

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[1]For a survey of the historical development of the multiplier concept prior to the work of Kahn, see Hugo Hegeland, The Multiplier Theory (Lund: C. W. K. Gleerup, 1954), Chapter 1, pp. 1-30.

[2]R. F. Kahn, "The Relation of Home Investment to Unemployment," Economic Journal, Vol. 41 (1931), pp. 173-198.

theory extended to a great variety of fields in economics, evidenced by a phenomenal growth in the literature on the theory and application of the multiplier for the past decades. The urban employment multiplier is a product of this major development of the multiplier analysis. The scope of the urban employment multiplier analysis is limited to an examination of the total local employment effects of changes in employment in export and investment sectors. The urban employment multiplier analysis emphasizes the interdependence of sectors within an urban economy and traces the stimulus originating in any one sector to all other sectors, both directly and indirectly.

In a broad sense, there are two major analytical approaches to the study of regional multipliers. One is associated with the use of regional input-output matrices and another with economic base studies. In general, the use of an input-output model is considered a comprehensive and sophisticated approach, but it is subject to many criticisms because of its important simplifying assumptions.[3]

[3]For comprehensive discussions on the limitations of input-output matrices, see O. Morgenstern, (ed.) Economic Activity Analysis (New York: 1954); Input-Output Analysis: An Appraisal, National Bureau of Economic Research Study in Income and Wealth, vol. 16 (Princeton, N. J.: Princeton University Press, 1958); and Robert Dorfman, "The Nature and Significance of Input-Output," Review of Economics and Statistics, vol. 36 (May 1954), pp. 121-33; for the regional and interregional application, see L. N. Moses, "The Stability of Interregional Trading Patterns and Input-Output Analysis," American Economic Review,

This study will adopt the economic base study approach, using multiple correlation and regression. Usually, the economic base approach distinguishes basic (or export) and non-basic (or local) activities on the premise that the growth of a region depends upon the activities in which goods and services are produced locally and exported outside the region. The basic activities provide not only the means of payment for the import of raw materials, goods and services which cannot be produced locally, but also income originating in basic activities will, to a large extent, determine the level of the service activities which are essentially locally oriented.

However, this study defines the base activities much more broadly than most other economic base studies. The study is concerned not only with the area employment effects of export activities, but also such effects of the investment sector. Most base studies measure the ratio of export employment against total employment, neglecting the importance of

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vol. 45 (December, 1955), pp. 803-32; Charles M. Tiebout, "Interregional Input-Output Model: An Appraisal," _Southern Economic Journal_, vol. 36 (October, 1957), pp. 140-147; and Walter Isard, "Interregional and Regional Input-Output Analysis: A Model of Space Economy," _Review of Economics and Statistics_, vol. 33 (November, 1951), pp. 322-24. Various references to input-output techniques are cited in Vera Riley and Robert L. Allen, _Interindustry Economic Studies: A Comprehensive Bibliography on Interindustry Research_ (Baltimore: John Hopkins Press, 1955).

the local investment sector. In essence, this study attempts to incorporate export employment effects explicitly into the Keynesian investment multiplier framework.

The development of the economic base study method was in large part due to the pioneering work of Homer Hoyt, who first developed the idea of a "basic-service ratio" in the 1930's.[4] As far as the application of regression to the economic base study is concerned, Daly's study in 1940 is the first one to apply the least squares method to regional multiplier analysis. Daly investigated the relationship between basic and non-basic employment in various regions in England, for the years 1921 and 1931.[5] Later, Hildebrand and Mace's 1950 study of Los Angeles[6] and Thompson's study of Lancaster County, Nebraska, in 1958,[7] adopted an analytical technique similar to Daly's. That is, they employed a simple regression technique whereby an

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[4] Homer Hoyt, <u>One Hundred Years of Land Values in Chicago</u> (Chicago: University of Chicago Press, 1933).

[5] M. C. Daly, "An Approximation to a Geographical Multiplier," <u>Economic Journal</u>, vol. 50 (June-September, 1940), pp. 248-58.

[6] G. Hildebrand and A. Mace, Jr., "The Employment Multiplier in an Expanding Industrial Market: Los Angeles County, 1940-47," <u>Review of Economics and Statistics</u>, vol. 32 (August, 1950), pp. 241-49.

[7] G. E. Thompson, "An Investigation of the Local Employment Multiplier," <u>Review of Economics and Statistics</u>, vol. 41 (February, 1959), pp. 61-67.

estimate of the employment multiplier was obtained by computing the simple regression of changes of non-basic employment on changes in basic employment. Most studies used a simple computation of a "basic-service ratio" for the derivation of employment multipliers.

B. The Problem

1. Statement of the Problem

The primary purpose of this study is to analyze through multiple regression estimation methods the multiplier effects on local employment in the St. Louis Standard Metropolitan Statistical Area resulting from monthly variations in investment and in the aerospace and other major export activities from January, 1958, to June, 1964.

2. Importance of the Study

As a result of the mushrooming growth of cities and metropolitan areas during the past several decades and the concomitant concentration of the nation's social and economic activities in these areas, it has become increasingly complex and difficult to make necessary adjustments to rapid social and economic changes, and to plan rationally for the vast array of urban government services. An urban employment multiplier analysis can serve the purpose of this rational planning to cope with newly emerging problems. Such an analysis offers valuable information for regional economic growth and business fluctuations by indicating the

current source of income and employment, and weakness in the regional economy. Information resulting from an urban employment multiplier analysis can be highly useful in making governmental decisions and in forecasting economic growth. In addition, an urban employment multiplier analysis can be readily incorporated into more specialized studies such as urban renewal, land use, transportation, water supply, and local government finances. In essence, the urban employment multiplier analysis can be used as an effective planning tool for sound urban growth.

C. General Organization of the Study

Chapter II deals with export employment estimates. The model for urban employment multipliers is developed in Chapter III. Chapter IV pertains to a statistical estimation of the model for urban employment multipliers developed in Chapter III. Since the study relies heavily upon regression estimation methods using time series data for the derivation of employment multipliers, a part of Chapter IV is devoted to a study of the use of error formulas with time series. In particular, a test of autocorrelation is applied to the residuals from the regression equations fitted. In Chapter V, the study utilizes multipliers obtained in an examination of the impact of a given employment change in the aerospace industry on the St. Louis area economy in terms of direct and indirect increases in the area employment. The results are summarized in Chapter VI.

CHAPTER II

EXPORT EMPLOYMENT ESTIMATES

Economic activities of the community can be dichotomized in terms of their exogenous and endogenous nature for analytical convenience. Koopmans divides the exogenous variable into two different categories depending upon the classification principle adopted. They are termed "the departmental principle" and "the causal pri ciple" respectively. Those variables remaining wholly or partly outside the domain of economics are classified exogenous in accordance with "the departmental principle." For instance, weather and climate, all types of geological catastrophes and natural disasters, technological changes, social and political events are placed under this category. On the other hand, "the causal principle" focuses on the causal relationship of a given set of activities. Thus, this principle treats as exogenous "those variables which affect the remaining (endogenous) variables but are not affected by them."[1]

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[1]T. C. Koopmans, "When is an Equation System Complete for Statistical purposes," Statistical Inference in Dynamic Economic Models, edited by T. C. Koopmans (New York: John Wiley and Sons, 1950), pp. 393-409.

In this study, "the causal principle" is adopted in classifying economic activities as either exogenous or endogenous. Exogenous activities are defined, as the term is used in this study, to include activities whose levels are not explainable in terms of other activity levels of the model or other economic indices affected by such activities (e.g. area income). In short, they can affect other activity levels but they cannot be affected by them. For instance, changes in the level of exports in the area aerospace industry can affect economic activity levels of the area consumption and service industries by affecting the area income, but variations in the activity levels of the latter cannot affect the export level of the former. Endogenous activities can be defined in a similar way. They are a set of activities whose levels of operation are to be explained by the model in terms of other activities or other economic indices. For example, most retail trade and local services are categorized as endogenous because of their heavy dependence upon the level of area income.

A. Export Sector

It goes without saying that one of the most important exogenous sectors for a community is its export sector. For instance, exports of military aircraft from St. Louis SMSA (Standard Metropolitan Statistical Area) would be a

case of the exogenous activity. The level of such exports is set by forces exogenous to the St. Louis SMSA, i.e., federal or foreign government demands for military aircraft. Such demands are usually determined for political and military reasons. In general, the level of exports appears to be determined by the external market demand as well as by supply.[2]

The study assumes the absence of feedback effects. The logic for such an assumption is that the community under consideration constitutes such a small part of the total market that it does not affect this market but is affected by it. This assumption may not be valid in the case of exports to immediate neighboring communities, but the magnitude of such feedback effects is likely to be inconsequential.

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[2]St. Louis may (or may not) affect demand for aircraft, but it is most likely to influence its market share, given extreme product differentiation in the aerospace industry. Actually, McDonnell Aircraft Corporation experienced a phenomenally growing market share of the Pentagon's shrinking aircraft procurement for the past decade. In fiscal 1954, out of a total of $9 billion worth of the Pentagon's expenditures for aircraft, McDonnell's share was only 1.3 percent or $115 million. In contrast, by fiscal 1964, McDonnell's contract awards had increased to $600 million, while the Pentagon's total aircraft procurement had been reduced to $6 billion. Thus, the company's market share had risen to 10 percent in fiscal 1964 from 3 percent in fiscal 1954. See _Fortune_, November, 1964, p. 139.

B. The Area Investment Sector

In addition to export industries, there are other important exogenous sectors, depending upon the time span chosen. In the short run, much of the area investment sector seems to be influenced by forces exogenous to a community such as interest rate, general credit conditions and other factors. In other words, many variations in the area investment are not adequately explainable in terms of the area income levels.[3]

Certainly income ultimately affects investment, but this association tends to be less pronounced in the short run than in the long run. Such an association is almost undiscernible in the short run (annual variations), but is clearly defined in the long run (decades) according to Tiebout's study.[4] The dependence of area investment upon area income is thus a function of time. The shorter the adjustment period chosen, the less dependence between income and investment is to be expected. All of this means

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[3]Generally speaking, a great majority of economic base studies are concerned with the ratio of export employment measured against total employment even in the short run. They tend to neglect other important exogenous sectors such as the area investment sector.

[4]Charles M. Tiebout, The Community Economic Base Study, Supplementary Paper No. 16, published by The Committee for Economic Development. p. 71.

that, for short-run analysis, export and investment income are taken as given, i.e., measured but not explained by the model. This applies particularly to this study which deals with monthly variations of economic activities.

Stated more specifically, the area investment sector consists of three component sectors: the area housing investment, the area business investment, and the area capital investment by governmental units. Variations in the housing investment are not sufficiently explicable on the basis of the community income level alone in the short run. Even with a constant level of community income, the volume of housing investment is likely to fluctuate from year to year due to exogenous factors such as interest rates, down payment requirements, in-and-out migrations, and building regulations.[5] Similarly, profit expectations influence the level of business investment and in the short run, expectations are determined by many factors in addition to current local income. The same reasoning applies to capital expenditures by all levels of governments (federal, state, and local) on items such as roads, schools, water mains, incinerators, and so on. They are more or less determined through the political proc ess.

In the long run, nevertheless, fluctuations in the

[5] *Ibid.*, pp. 57-60.

investment sector are likely to be associated with area income and its rate of growth. This is particularly true of housing construction and government capital expenditures. Less obvious is the case of business investment. That part of business investment related to the area consumption sector tends to be related to the area income levels in the long run. The expansion of plant and equipment would occur in order to meet increasing local demands accompanied by the community growth. However, even in the long run, business investment in export sectors would not be determined by forces endogenous to a community, but by the growth rate of the external market demands. Therefore, the breakdown of business investment into investment in local consumption sectors and in export sectors would be necessary.[6]

C. Short Run V.S. Long Run Analysis

Economists find it important to discuss the way in which certain economic activities respond to changes in the levels of other economic activities in connection with the passage of time. The Marshallian concept of three periods of time in supply analysis is an often-cited example: the market period during which output level cannot vary; a short

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[6]For a comprehensive discussion on the behavior of area investment sector as well as other sectors, see Charles M. Tiebout, op. cit., Chapter VI, pp. 57-75.

run during which output can be varied but plant size cannot; a long run in which all factors are variables. The introduction of time into economic analysis brings into sharper focus the nature of a series of adjustments which are set in motion by some economic variables in response to changes in other variables.

However, the division between short run and long run time spans involves a high degree of arbitrariness. Tiebout suggests that as a rule of thumb, short run analysis covers usually periods from a few months up to around two years. Long run analysis extends from five to ten or twenty years.[7] On the basis of Tiebout's classification scheme, this study will be considered a short run analysis, since it is concerned with month to month variations. Therefore, the area investment sector would be treated as exogenous in this study within the framework of short run analysis.

D. Other Exogenous Sectors

Net factor payments and net transfer payments to the area may have important bearings upon local employment as exogenous variables. Net factor payments to the area refers to employee compensation and property income received from outside the area less the total of such

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[7] Ibid., p. 57.

payments made from the area to the rest of the world. Net transfer payments to the area pertains to such items as private gifts and government transfer payments from outside the area less gifts and tax payments from the area to the rest of the world. The great bulk of transfer payments [illegible] in the form of gifts and government payments,[8] and most factor payments such as various property incomes can be reasonably assumed to be exogenous to a community. Furthermore, the net inflow of income from such sources, as in the case of export receipts, will initiate a series of income propagation through multiplier effects, and increase local employment accordingly. Unfortunately, monthly data for transfer payments and property income at the regional level are non-existent. Therefore, the incorporation of such variables into a short-run framework would not be possible at this time.

E. Division of Export and Local Employment

The method used to divide employment into export and local employment has significant effects on the outcome of the multiplier analysis. Export employment, as defined in

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[8]That part of the area unemployment insurance payments associated with employment variations in the exogenous sectors (export and investment sectors) should be classified as exogenous, and the remainder as endogenous.

this study, is employment serving markets outside the St. Louis SMSA. The market orientations for certain industries in the area are readily identifiable on *a priori* grounds. Aircraft and parts, and ordnance and accessories industries belong to this category; they export 98 percent of their products to the Federal Government,[9] and all employment in such industries will be classified as export employment. The exports of an area include not only goods sold abroad but goods and services sold in the area to non-residents and to "foreign" governments. Therefore, most federal and state government employees in the area, except postal workers, are treated as export employment due to the fact that they sell their services to foreign (state and federal) governments. Demands of state or federal governments for such services are assumed to be exogenous to the area. However, postal services contain predominantly an endogenous element, because the allocation of postal workers depends largely upon the community size. Hotel and lodging places in the area are treated similarly as an export industry, since they primarily serve non-residents. In view of a close association between the number of local government employees on one hand and the community size and its growth on the other, all local government employees are assumed to be local.

[9] *Fortune*, November, 1964, p. 137.

employment. In other words, demands for local government services are explainable in terms of the community income level.

The construction industry raises some peculiar problems despite the fact that it produces for a local market. According to the Bureau of Labor Statistics classification scheme, the construction sector is subdivided as follows:[10]

S.I.C. Code No.	Description
15	General Building Construction
16	Heavy Construction
161	Highway and Street Construction
162	Other Heavy Construction
17	Special Trade Construction
	Plumbing, Heating, and Air-Conditioning
	Electrical Works
	Masonry, Stonework, Tilesetting and Plastering
	Other special trade construction

[10]U. S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings Statistics for the U.S. 1909-62, issued 1963, Bulletin No. 1312-1, pp. 24-31.

This classification contains major characteristics of the area investment sector discussed before. As explained before, the area investment sector is composed of three major components: housing investment, business investment in plant and equipment, and capital investment by governmental units. The construction of residential, farm, industrial, commercial, public or other buildings is included (except when performed by "force account" and listed under other industries) under the heading of General Building Construction (SIC 15). Therefore, it contains some element of each major component of the area investment sector. That portion of Heavy Construction (SIC 16) related to highway and streets, bridges, sewers, water mains, and other capital improvements corresponds closely to capital investment by governmental units in the area investment sector. In addition, it includes various heavy constructions of business units other than building construction. Finally, Special Trade Construction (SIC 17) involves the installment of equipment as well as the maintenance of capital.[11] Consequently, the construction industry will be classified as an exogenous sector within the framework of short run analysis.

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[11]Bureau of the Budget, Standard Industrial Classification Manual (Washington: U. S. Government Printing Office, 1957), pp. 35-40.

On the basis of *a priori* reasoning, several industries in the area have been so far identified as either entirely exogenous (mainly export) or local (endogenous) sectors. However, export employment estimates for the rest of industries in the area are not easily obtainable by the application of such a method. Either direct survey methods or indirect methods must be employed to measure export employment for the remaining industries.

Three indirect methods to measure export sectors have been commonly used:

[1] the judgment approach;

[2] location quotients with a wide variety of variations;

[3] the minimum requirements technique.[12]

The judgment approach is the simplest. The division of export and local employment is made simply on the basis of an arbitrary judgment, usually specialized knowledge of the author.[13] As illustrated previously, the judgment approach was employed in this study for the selection of certain export industries on *a priori* grounds.

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[12]For a systematic and comprehensive treatment of indirect methods to measure export employment, see Federal Reserve Bank of Kansas City, "The Export-Local Employment Relationship in Metropolitan Areas," *Monthly Review* (March, 1960), pp. 1-8. See also J. M. Mattila, and W. R. Thompson, "Measurement of the Economic Base of the Metropolitan Area," *Land Economics*, vol. 31 (August, 1955), pp. 215-28.

[13]For a partial use of this method, see Federal Reserve

Location quotients are most commonly used to measure export employment.[14] Sometimes they are called coefficients of localization or specialization. There are a wide variety of variations of this method, ranging from the simple location quotients with respect to national averages to those involving the multi-benchmark method.[15] The underlying notion is simple. A location quotient of 1.00 would mean that employment in that industry shows no greater concentration in the subject economy than in the benchmark economy, and thus no export activities involved. For a quotient exceeding

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Bank of Kansas City, "The Employment Multiplier in Wichita," Monthly Review, vol. 37 (September, 1952), pp. 1-7.

[14]The location quotient is a ratio of the employment in a given industry as a percent of total employment in that economy to employment in the same industry as a percent of total employment in a benchmark economy:

$$\frac{e_i}{e_t} \Big/ \frac{E_i}{E_t}$$

e_i is the area i^{th} industry employment
e_t is the area total employment
E_i is the benchmark economy i^{th} industry employment
E_t is the benchmark economy total employment.

A benchmark economy refers to the economy with which "subject" economy, i.e., the area economy, is being compared.

[15]For the use of the multi-benchmark methods, see G. Hildebrand and A. Mace, Jr. "The Employment Multiplier in an Expanding Industrial Market: Los Angeles County, 1940-47," Review of Economics and Statistics vol. 32, (August 1950), pp. 241-49; and G. E. Thompson, "An Investigation of the Local Employment Multiplier," Review of Economics and Statistics (February, 1959), pp. 61-67.

1.00, greater specialization is indicated in the subject economy relative to the benchmark economy. Therefore, some portion of employment in that industry is assumed to be export employment.

The location quotients method has been a frequent target of criticism in the professional journals due to its many apparent defects: (1) the assumption of uniform demand throughout the nation; (2) the assumption of uniform productivity; (3) heavy dependence of location quotients upon the SIC digit level, i.e., the problem of product mixes.

The minimum requirements approach begins with the selection of a group of cities roughly comparable in terms of population or other indices and the percentage of labor force employed in each industry is calculated for each city. Next, the percentages for a given industry are ranked in decreasing order of magnitude. Then, the lowest percentage or some point in the array is to be taken as the minimum requirement by any city to be self-sufficient. All employment in any community above this amount is presumed to be export employment (surplus workers).[16] The

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[16]Edward L. Ullman and Michael F. Dacey, "The Minimum Requirements Approach to the Urban Economic Base," Papers and Proceedings of Regional Science Association, vol. 6 (1960), pp. 175-194.

serious problem involved in this approach is the proper demarcation of the cutoff point, since not all cities selected are likely to be alike in all respects.

In general, indirect methods are simple and inexpensive, but their limitations are often too serious to be assumed away, as some of them were already discussed previously in connection with location quotients methods.[17] On the other hand, direct surveys of firms and consumers to estimate export employment, despite their merits, entail usually a high cost and are too time-consuming to be considered for this study. As a way out of this dilemma, this study will utilize data on local sales to nonlocal sectors contained in the 1955 St. Louis SMSA input output table. Information concerning export sales in dollars for each industry in the table were obtained primarily through the direct surveys of major firms in the area.[18]

There is a significant advantage in using the input-output table, which would be almost impossible to secure by any other approach. The use of a structural

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[17]For a detailed discussion on the limitations of indirect methods, see Walter Isard, Methods of Regional Analysis (Cambridge, Mass.: M.I.T. Press, 1963) chapter VII, pp. 232-308; also refer to Charles M. Tiebout, op. cit., pp. 46-49.

[18]John C. Bollen, (ed.), Exploring The Metropolitan Community (Berkeley & Los Angeles: University of California Press, 1961), pp. 373-375.

matrix will enable us to estimate all employment indirectly tied to export activities. Local employment linked to direct export activities (for instance, purchase of local products by the area export industries as inputs) can be estimated by multiplying down each column of the inverse matrix by an export coefficient of the industry named on the top of each column, and then making row summations of all coefficients in each row. Each row summation represents indirect export (sales or employment) as a percent of the total for each industry named on the left of each row in the inverse matrix.[19]

However, two assumptions would have to be made before the export matrix be used for export employment estimates: (1) the ratio of export sales to total sales corresponds approximately to the ratio of export employment to total employment for each industry;[20] (2) the 1955 export coefficients in the input-output table are still applicable to the study period of 1958-1963. The first assumption seems to be reasonable, since export sales and export employment tend to move in the same direction.

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[19]For a formal mathematical derivation of export-linked employment coefficients, see Appendix A of this study.

[20]For a theoretical discussion on the necessary and sufficient conditions for employment ratios and sales ratios to be identical, see Edwin Terry, Homer Hoyt's Urban Employment Multiplier, unpublished doctoral dissertation (Iowa State Univ., 1962), pp. 63-65.

Also, it is unlikely that the St. Louis area economy has undergone fundamental structural changes sufficient to unwarrant the second assumption. The following studies are cited in support of the above statement. According to the 1955 Metropolitan Survey Study, exports accounted for about 26 percent of the St. Louis area's 1955 output.[21] A highly diversified economy with relatively small over-all export percentages such as the St. Louis Area economy would be less vulnerable to economic fluctuations originating in regional or national economy than a specialized economy marked by heavy export activities. Ullman computed an index of specialization for 19 largest metropolitan areas of the United States, using 1950 Population Census data. The index ranged from 8.14 for Washington, D. C. and Detroit to 1.84 for San Francisco-Oakland. The higher the number, the more specialized. St. Louis with an index of 2.87 ranked tenth in the degree of specialization. Ten metropolitan areas were placed within the range of 1.48-2.87, and nine others within the range of 3.58-8.14.[22]

It is fortunate that the industrial classification of the 1955 input-output table is very similar to the classification system adopted by Missouri Division of Employment and Security at St. Louis for the preparation of monthly

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[21]John C. Bollen, <u>op. cit.</u>, pp. 466-471.

[22]Edward L. Ullman, <u>op. cit.</u>, p. 190.

estimates of employment for the St. Louis SMSA. However, some sector aggregation was required to make them comparable, but without damaging the over-all sensitivity of the classification design adopted originally.

Where the sector aggregation is needed as in the case of this study, the aggregate input coefficient for the sectors aggregated is found by simply summing a_{ij} (input coefficients) of each component over a column. This column summation of input coefficients stands to reason. If a unit increase in demand for good j affects the output i_1 by $a_{i_1 j}$ units and the output of i_2 by $a_{i_2 j}$ units, then the total effect of a unit increase in demand for good j affects industries $i_1 + i_2$ by $a_{i_1 j} + a_{i_2 j}$. However, the same procedure can not be followed in case of the inverse coefficients. With different methods of aggregation, different results are obtained for the inverse coefficients. On intuitive grounds, it can be readily seen that the value of an inverse coefficient is related to that of every other coefficient in the matrix. Balderston and Whitin provided a lengthy formal mathematical proof and examples of this particular problem.[23] Therefore, a new

[23] J. B. Balderston and T. M. Whitin, "Aggregation in the Input-Output Model," *Economic Activity Analysis*, edited by Oskar Morgenstern, (New York: John Wiley & Sons, 1954), pp. 102-128.

inverse matrix was computed to derive the indirect export employment coefficients (α_i''), since the study involved some sector aggregation of the St. Louis Input-Output Table in order to make the table comparable to the employment data collected for the study.

Unlike the 1955 St. Louis input-output table, the household sector was removed from the structural matrix in the computation of a new inverse matrix in order to eliminate the income-induced effects in the inter-industry relationships. The logic for the above procedure is that the income-induced effects are incorporated into the statistical estimation of the multipliers through multiple regression methods for major export sectors.

In summary, the two different criteria for the export-local employment classification can be adopted.

Case I: Only direct export employment coefficients (α_i) are used for the division of each industry employment into the local and nonlocal components. Algebraically stated:

$$X_i = \alpha_i X_i + (1 - \alpha_i) X_i \qquad 0 \leq \alpha_i \leq 1$$

where X_i is total employment in industry "i" and α_i is direct export employment coefficient.

The multipliers obtained by Case I method include both inter-industry effects and income-induced effects.

Case II: Not only direct export employment, but all indirect export-linked employment are classified as exogenous employment.

Algebraically expressed:

$$X_i = \varphi_i X_i + (1 - \varphi_i) X_i \qquad 0 \leq \varphi_i \leq 1$$

where $\varphi_i = \alpha_i + \alpha''_i$ is direct and indirect export employment coefficient.

The multiplier values estimated by Case II method will be affected only by the income-induced effects, since the inter-industry effects (export-linked employment) are taken into account in the classification of export and local employment in advance of the multiple regression analysis.

Table 1

Relative Importance of Export Employment for the St. Louis SMSA, 1963

S.I.C. Code #	Industry #	Description of Industry	α_i	α'_i	α''_i	$\varphi_i(\alpha_i+\alpha''_i)$	Total Employment (1963)
372	*1.	Aircraft and Parts	100.00			100	30,300
19	*2.	Ordnance and Accessories	100.00			100	3,500
	*3.	Postal Workers	0.00				12,300
91 & 92	*4.	Federal and State Government Employees except postal workers	100.00			100	20,200
93	*5.	Local government employees	0.00	5.79	5.92	5.92	50,900
15- 17	*6.	Construction (investment sector)	100.00	(12.52)	13.23	100	36,300
20	7.	Food & Kindred Products	64.83	4.54	4.81	69.64	29,000
22 & 23	8.	Textile and Apparel	59.00	7.39	7.88	66.88	13,600
28	9.	Chemicals	84.96	10.44	10.81	95.77	21,300
29	10.	Petroleum & Related Industries	73.20	8.55	8.86	82.06	4,300
31	11.	Leather & Leather Products	90.36	5.36	5.66	96.02	9,500
34	12.	Fabricated Metals	36.33	13.36	13.71	50.04	17,200
35	13.	Machinery Except Electrical	48.62	9.71	10.10	58.72	18,000
33	14.	Primary Metals	69.30	20.54	21.63	90.93	25,800
36	15.	Electrical Machinery	82.31	3.51	3.56	85.87	15,400
371	16.	Motor Vehicles & Equipment	42.10	9.76	11.08	53.18	18,700
370	17.	Other Transportation Equip.	79.86	2.22	2.26	82.12	3,300
24 & 25	18.	Lumber & Furniture	29.26	3.97	4.04	33.30	5,100
26	19.	Paper & Allied Products	31.06	10.17	10.70	41.76	8,600
27	20.	Printing & Publishing	31.56	6.26	6.59	38.15	13,700
	21.	Miscellaneous Manufacturers	39.26	33.48	37.58	76.84	20,700
40	22.	Railroad Transportation	57.08	15.51	15.97	73.05	17,900
41- 47	23.	Other Transport. Service	25.39	8.60	8.70	34.09	26,200
60- 67	24.	Finance, Insurance & Real Estate	1.94	9.99	10.26	12.20	39,700
50- 59	25.	Wholesale & Retail Trade	9.60	13.61	14.00	23.60	152,800
48 & 49	26.	Communication, Electricity, Gas & Sanitary Services	14.58	11.95	12.21	26.79	18,700
71- 90	27.	Services & Miscellaneous	2.88	10.61	10.89	13.77	109,200

Miscellaneous Manufacturers include: Agriculture; Tobacco; Rubber; Stone, Clay and Glass Products; Instruments and Related Industries; Miscellaneous; and Undistributed.

* *a priori* classification

α_i = direct export employment coefficients

α'_i = the first export-linked employment coefficients

α''_i = the total indirect export employment coefficients

$\varphi_i(\alpha_i+\alpha''_i)$ = direct and indirect export employment coefficients

Sources: The 1955 St. Louis Input-Output Table and Monthly Employment Statistics, 1958-1964, for the St. Louis SMSA.

CHAPTER III

DEVELOPMENT OF THE MODEL FOR URBAN EMPLOYMENT MULTIPLIERS

A. Employment Multiplier Hypothesis

The income multiplier hypothesis states that changes in the income flows in exogenous sectors produce a series of income changes in endogenous sectors and result in a multiple of the original change after a lapse of a given time. Furthermore, the hypothesis asserts that the multiple of the original change is greater than one. Stated in a slightly different way, there exists an important explanatory dependence in the sense that through the multiplier process, the income created in endogenous sectors is assumed to be determined by local spending out of the income originating in the exports or the area investment sector. Therefore, if variations in employment correspond approximately to variations in income flow, one would expect to find the explanatory dependence between employment in exogenous sectors and employment in endogenou sectors, and an increase in employment in exogenous sector will increase the total area employment by an amount greate than the initial increase in employment (thus a multiplier

coefficient greater than 1.00).[1]

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[1]Employment, income, sales, value added, payrolls, and other information can be used as measurement units of economic activities. All of the measures tend to move in the same direction, but in different magnitudes. The conceptual problems involved in choosing one or the other unit are worth being examined briefly.

Employment as a unit of measurement is most widely used, but it may not be so sensitive in reflecting business fluctuations as income accruing to residents in the form of wages and salaries, dividends, interest, rents, etc. Employment as a unit would not reflect inter-industry differences in productivity, wage levels, and overtime. Despite its defects, it has many compensating advantages. Employment data are readily available and are often the only available information (which is the major reason for the selection of employment as a unit of measurement for this study). Furthermore, employment is one of the most important magnitudes with which planners and policy-makers must be concerned. Finally, from a local planning point of view, employment is a basic determinant of demographic changes such as in-and-out migration, marriages, divorces, and so on.

Although income as a measurement unit is preferred to employment, income data may not be as all inclusive as a value added type of measure, since data on property income are extremely difficult to obtain, at least at the regional levels.

Perhaps, the value added unit is one of the most conceptually acceptable measures. It avoids the problem of double-counting as in the case of sales used as a measure. Value added by industry is roughly comparable to national income originating in this industry and thus gives a measure of the community income. However, since value added is inclusive of corporate profits, there is a minor problem of allocating corporate profits to each region according to the geographical distribution of ownership.

For an extensive discussion on conceptual and technical difficulties involved in the choice of measurement units, see Richard B. Andrew, "Mechanics of the Urban Economic Base: The Problem of Base Measurement," Land Economics, (February 1954), pp. 52-60.

In the light of a functional relationship postulated between exogenous and endogenous employment, an estimate of the area employment multipliers may be obtained by regressing changes of endogenous (local) employment on changes of exogenous (export and investment) employment. More specifically stated, an attempt will be made to measure the multiplier effects on local employment in the St. Louis SMSA resulting from monthly variations in export and investment sectors during the period of 1958-1964.

B. Development of Working Hypotheses

In the previous chapter, direct and indirect export employment coefficients for each industry in the area were derived and these coefficients were used to divide monthly employment estimates of each industry (from January, 1958 to June, 1964) into local and nonlocal components.[2]

Mathematically stated:

Case I: $X_i = \alpha_i X_i + (1 - \alpha_i) X_i \qquad 0 \leq \alpha_i \leq 1$

Case II: $X_i = \varphi_i X_i + (1 - \varphi_i) X_i \qquad 0 \leq \varphi_i \leq 1$

where α'_i is direct export employment coefficient
α''_i indirect export employment coefficient, and $\varphi_i (\alpha'_i + \alpha''_i)$ direct and indirect export employment coefficient.

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[2]See pp. 25-26.

Three regression models with one unit time lag between local and nonlocal employment will be used to estimate urban employment multipliers. Expressed in mathematical equations:

Model I: $Y_t = a + b_1 \alpha_1 X_{1\ t-1} + \ldots + b_n \alpha_n X_{n\ t-1}$

$+ b_{n+1} X_{n+1} + b_{n+2} X_{n+2} + \ldots + b_{n+12} X_{n+12}$

$(t = 1, 2, \ldots, q)$

where $Y_t = \sum_{i=1}^{n} (1 - \alpha_i) X_{it}$ is the area total local employment; X_{n+1} trend factor; and $X_{n+2} - X_{n+12}$ dummy variables for seasonal factors.

Model II: $Y_t = a + b_1 \sum_{i=1}^{n} \alpha_i X_{i\ t-1} + b_2 T + b_3 X_3 + \ldots$

$+ b_{13} X_{13}$ where $X_3 - X_{13}$ are dummy variables for seasonal adjustments, and T trend.

Model III: $(1 - \alpha_i) X_{it} = a + b_1 \alpha_i X_{1\ t-1} + \ldots +$

$b_n \alpha_n X_{n\ t-1} + b_{n+1} X_{n+1} + b_{n+2} X_{n+2} + \ldots +$

$b_{n+12} X_{n+12}$

Model I takes the form of a multiple regression equation by disaggregating the total area nonlocal employment into major export industries and the investment sector (construction industry). The above multiple regression model will enable us to estimate a net relationship between any specific export industry (for instance, aircraft industry) and the area total local employment, partialling out other export industries effects and other factors affecting local employment. Model II will regress changes of the area total local employment on changes of total nonlocal (exogenous) employment. The regression coefficient obtained would be a gross average multiplier for the entire export sector and the investment sector, and it would not necessarily apply to any specific export activity. More strictly speaking, all the area export employment are grouped into one aggregate called "basic employment", and similarly all the local employment into "non-basic employment". Therefore a regression coefficient for the model II represents an aggregate multiplier for the basic employment as a whole (or the entire exogenous sectors). This method has been most commonly used in the economic base studies.[3] The method assumes implicitly that an employment increase in any export industry would affect equally the local employment

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[3]Cf. Hildebrand and Mace, op. cit., pp. 241-49 and Thompson, op. cit., pp. 61-67.

The method does not allow for differential impacts of each export industry upon the local employment resulting from inter-industry differences in factor income payments, productivity, the consumption habits of employees, etc.

Model III is identical with Model I on the right side of the equation. However, on the left side, each major local employment component is substituted for the area total local employment as dependent variable. This model is conceived primarily for the purpose of delineating the employment impact of a given major export industry (especially, aircraft industry) upon a specific major local (endogenous) employment. The following industries are tentatively selected as major local industries to be admitted into the equation as dependent variable, since they comprise the major components of the area consumption sector:

S.I.C. Code #	Description of Industry	α_i	Total Employment (1963)
60-67	Finance, Insurance & Real Estate	1.94	39,700
50-59	Wholesale and Retail Trade	9.60	152,800
48-49	Communication, Gas, Electricity & Sanitary Services	14.58	18,700
41-47	Local Transportation Service	25.39	26,200
71-79	Business & Personal Services	2.88	109,200

In order to determine the probable magnitude of export-linked employment effects (often called inter-industry effects or indirect export effects), another statistical estimation of the Model II will be carried out, using this time direct and indirect export employment coefficients ($\alpha_i + \alpha_i'' = \varphi_i$) for the division of industry employment into local and nonlocal parts. Expressed in mathematical notations:

$$\text{Model II}^{i}: \quad Y_t = a + b_1 \sum_{i=1}^{n} \varphi_i X_i \qquad + b \quad T + b \quad Y +$$

$$+ b_{13} X_{13}$$

where φ_i ($\alpha_i + \alpha_i''$) are direct and indirect export employment coefficients and T trend variable.

C. The Introduction of a Time Lag

Complex interactions among multifarious economic activities involve usually some form of time lags and instantaneous adjustments are rather uncommon phenomena in the real world. In this context, the time dimension assumes a crucial importance in economic analysis. Unfortunately, very little has been empirically determined about the probable nature of various lags and their stability over time. One can build a wide variety of lags into the

model, depending upon various assumptions to be made with regard to consumption function, production function, economic structure, and other factors governing lags.

It is interesting to note that in the absence of a time lag, model I is a mathematical identity, provided all industries in the area contain both local and nonlocal employment. In such a case, a net regression coefficient (multiplier) for each export industry can be readily obtained by simply computing the ratio of export employment percentage to local employment percentage, i.e., $1 - \lambda_i / \alpha_i$, without going through a time-consuming multiple regression analysis.[4]

The study will introduce one unit time lag in export-local employment relationship. One period time lag is chosen, partly because of its simplicity and convenience in terms of the statistical implementation of the study, and partly because of lack of information on the behavior of various distributed lags.

However, the length of a time lag poses a difficult problem. Fortunately, Metzler identified and estimated empirically the relative length of three major lags in

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[4]For a mathematical proof, see Appendix B of this study.

flow of income, which bears some relevance to this study.[5] The first type of lag is called a "consumption lag", which deals with a lag in consumers' expenditures behind income payments. Suppose that the initial change takes the form of additional payments to factors of production in the area export industries resulting from an increase in net external receipts. Recipients of such income will increase eventually their consumption expenditures, but at different time periods, depending upon the consumers' expectation, inertia, habit, etc. Therefore, to the extent that there is a delay in the consumption expenditures, the income propagation process through multiplier effects is brought to a halt temporarily.

Metzler found little evidence of a consumption lag in his study, when quarterly data of consumption are compared with income payments for the period of 1929 to 1938. Consumption appeared to be dependent largely upon income of the same quarter. He inferred from these data that the lag in consumption is considerably less than a three month period.[6] Similarly, D. H. Robertson, with whom the expenditure lag is usually associated, assumed a lag of one day in

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[5] Lloyd A. Metzler, "Three Lags in the Circular Flow of Income," Income, Employment and Public Policy, Essays in Honor of Alvin H. Hansen (New York: W. W. Norton & Co., Inc., 1948), pp. 11-32.

[6] *Ibid.*, p. 22.

the expenditure of income behind its receipt.[7]

The second category of lag in the circular flow of income is the lag in output behind a change in sales. The length of output lag was estimated by comparing quarterly figures of net national product with the total of manufacturers' and retailers' inventories (wholesalers' inventory data unavailable then) for the period of 1921 to 1938. The logic behind this method is that both at the upturn and downturn of a business cycle, the discrepancy between output and sales takes the form of variations in inventory. Therefore, the upward (downward) movement in inventory after the close of rising (falling) income is indicative of the lag in output. This method did not separate intended changes in inventory for speculative purpose and for other reasons from the changes which result from a temporary discrepancy between sales and output. However, Metzler showed persuasively a number of examples to the effect that a particular movement of inventories in the period 1921-1938 was unlikely to be an intended movement.[8] His empirical evidence suggests that the output lag is much more pronounced than the consumption lag in quarterly data, and the former probably longer than

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[7] D. H. Robertson, Banking Policy and Price Level, p. 59.

[8] Metzler, op. cit., pp. 25-28.

a three-month period.[9]

The third lag is concerned with the lag in the distribution of profits. Apart from the fact that it is difficult to obtain empirical data concerning the lag in the distribution of dividend payments, the influence of this lag on the income propagation was heavily discounted by Metzler due to the high propensity to save on the part of business units.[10] Perhaps, in view of the small amplitude of fluctuations in dividend payments, relative to fluctuations in corporate profits, the exact length of the lag in dividend payments would not be a matter of great importance.

The Metzler's first two lags, consumption and output lags, seem to be adequately comparable to the non-local-local employment lag in this study. This comparability can be easily visualized if one traces through a series of income propagation processes set in motion by the initial stimulus in any exogenous sector. Assume that there is an increase in the Federal Government demand for military aircraft produced in the area. First, such an increase in demand would lead to expansion of employment and other factors of production in the aircraft industry,

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[9] *Ibid.*, p. 27.

[10] *Ibid.*, pp. 28-30.

and accordingly an increase in factor payments. Factor income recipients would eventually spend a part of their income on goods and services in the area. This local spending out of the income originated in the aircraft industry would complete the consumption lag discussed by Metzler. Next, the increase in the consumption expenditure on the part of the aircraft industry employees corresponds to an increase in sales, which would, in turn, result in the expansion of output through the transmission of increased orders from retailers through wholesalers to producers. Finally, an increase in output for the area consumption sector would induce the expansion of local employment, and thus complete the output lag.

It would be extremely hazardous to pinpoint the exact length of the consumption lag and output lag. Nevertheless, in the light of empirical data examined and also *a priori* grounds, the consumption lag seems to be negligible, perhaps much shorter than a quarter period as indicated by Metzler, and the output lag somewhat longer than the same period. One could make an educated guess that the probable average length of time for both lags combined may range from a one-month to a six-month period or slightly longer. Tentatively, the study will attempt to introduce various different lengths of time lag on the trial and error basis in order to determine which one of them would represent the best empirical statement of the export-local employment relationship.

CHAPTER IV

STATISTICAL ESTIMATION OF THE MODEL FOR URBAN EMPLOYMENT MULTIPLIERS

A. Study Area Delimitation

The delimitation of an appropriate study area poses numerous problems, both technical and theoretical, for any regional impact study.[1] The nature and levels of economic activities are highly dependent upon the way the study area is demarcated. For example, in case of a small residential commuter community contiguous to the core city, virtually all economic activities are exogenously determined and little endogenous activity exists. That is to say, exports of their factor services to the core city or neighboring communities are a predominant economic activity of the community in question and its level is determined by forces exogenous to the community, i.e., levels of economic activities of the core city or surrounding communities. However, as the delimitation of the study

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[1]For a comprehensive treatment of various technical and theoretical problems involved in the study area delimitation, see Richard B. Andrew, <u>op. cit.</u>, pp. 309-319.

area becomes broader, the scope of the area export activities becomes narrower. There are no export activities in the completely closed system in which the world as a whole is chosen as a study area.

The principal problem seems to consist in the selection of a proper criterion according to which the study area is demarcated. The adequacy of such a criterion depends upon the purpose of the study undertaken. The study area defined by relatively "pure" economic criteria may not necessarily agree with boundaries drawn by equally pure social criteria. However, in economic studies such as this one, the guiding principle for the study area delimitation should emphasize the concept of integration and interdependence of productive activities within the economic area. In other words, the outer limits of the study area should be determined by the range of interdependence of economic activities within the economic community.

The area chosen for this study is the St. Louis Standard Metropolitan Statistical Area, which consists of St. Louis City, St. Louis County, St. Charles County in Missouri, and Madison and St. Clair counties in Illinois. Surrounded by a very sparsely populated and mainly agricultural hinterland, the area is considerably isolated from other metropolitan areas or competing urban areas of

any form. Very little labor mobility seems to exist between the metropolitan area and adjacent areas.[2] In many respects, the St. Louis SMSA is regarded as a distinct, closely integrated, economic entity.

B. The Data Sources

The employment data collected for this study are monthly employment statistics for the St. Louis SMSA, covering the study period of January, 1958 to June, 1964. They were prepared monthly by the Missouri Division of Employment Security in St. Louis. The employment statistics concern estimates of wage and salaried nonfarm employment by industry, excluding proprietors and the self-employed, but farm employment statistics for the St. Louis SMSA were collected separately from the same office designated above. The employment estimation method used for the preparation of these data by the Missouri Division of Employment Security is explained in detail in appendix C of this study. The collected data were classified into the exogenous and endogenous employment by industry in the manner described in Chapter II. Then, they were fitted to multiple regression and correlation for the statistical estimation of the model developed in Chapter III with the aid of the IBM 7072 computer at the Washington University

[2] John C. Bollen, op. cit., p. 373.

Computer Center in St. Louis. A stepwise multiple regression method was employed for programming the data.[3]

C. Identification of the Variables

The following set of dependent and independent variables are used in the employment multiplier estimating equations.

The dependent variables are:

Y_1 = the area total local employment [$Y_1 = \sum_{i=1}^{n} (1 - \alpha_i) X_i$ in case of using direct employment coefficients and $Y_1 = \sum_{i=1} (1 - \varphi_i) X_i$ in case of direct and indirect export and employment coefficients].

Y_2 = total local employment in insurance, finance, and real estate industries

Y_3 = total local employment in wholesale and retail trade industries

Y_4 = total local employment in communication, gas, electricity and sanitary services industries

Y_5 = total local employment in local transportation services industries

Y_6 = total local employment in business and personal services industries.

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[3]This is a complete Fortran program which performs a multiple linear regression upon the input data. The included stepwise regression procedure yields intermediate regression equations, adding one variable at a time. The variable added at each step is the one which is expected to make the best improvement in the fit.

The independent variables are:

X_1 = total employment in aircraft and parts industries

X_2 = total export employment in chemicals and allied products industries

X_3 = total export employment in primary metals industries

X_4 = total export employment in electrical machinery industries

X_5 = total export employment in railroad transportatic service industries

X_6 = total federal and state governments employees

X_7 = total export employment in textile and apparel industries

X_8 = total export employment in machinery (except electrical) industries

X_9 = total employment in the area investment sector

X_{10} = total export employment in miscellaneous industries

X_{11} = trend

X_{12} - X_{22} = dummy variables for seasonal adjustments

X_{23} = the area total exogenous employment ($\sum_{i=1}^{n} \lambda_i X_i$ or $\sum_{i=1}^{r} \varphi_i X_i$)

D. Empirical Results and their Analysis and Interpretation

The estimated equations over the sample period of January, 1958 - June, 1964 in hundreds of persons are:

Equation (1)

$$Y_{1t} = 3449.1250 + \underset{(0.3196)}{0.8256}\ X^{*}_{1\ t-1} + \underset{(0.9235)}{0.1314}\ X_{2\ t-1} + \underset{(0.6120)}{0.8470}\ X_{3\ t-1}$$

$$+\underset{(0.8963)}{2.7112}\ X^{*}_{4\ t-1} + \underset{(2.062)}{1.0579}\ X_{5\ t-1} - \underset{(0.3932)}{0.0383}\ X_{6\ t-1} + \underset{(2.140)}{4.0377}\ X_{7\ t-1}$$

$$+\underset{(1.640)}{2.1582}\ X_{8\ t-1} + \underset{(0.2193)}{0.4324}\ X^{*}_{9\ t-1} - \underset{(0.2316)}{0.3756}\ X_{10\ t-1} + \underset{(0.6185)}{4.4176}\ X^{*}_{11}$$

$$+\underset{(15.67)}{52.1399}\ X^{*}_{12} + \underset{(15.67)}{78.1275}\ X^{*}_{13} + \underset{(15.73)}{123.7589}\ X^{*}_{14} + \underset{(15.73)}{81.7381}\ X^{*}_{15}$$

$$+\underset{(16.90)}{64.8280}\ X^{*}_{16} + \underset{(20.45)}{88.0518}\ X^{*}_{17} + \underset{(21.22)}{85.9692}\ X^{*}_{18} + \underset{(19.69)}{50.2291}\ X^{*}_{19}$$

$$+\underset{(19.54)}{117.1790}\ X^{*}_{20} - \underset{(19.07)}{22.6701}\ X_{21} - \underset{(16.46)}{24.6820}\ X_{22}$$

$t - (t -1) = 3$ month

$R^2 = 0.96$

Standard error of $Y_{1\ t} = 22.9233$

Degrees of freedom = 52

Equation (2A)

$$Y_{1t} = 3450.0291 + 0.4758\ X^{*}_{23\ t-1} + 3.7700\ X^{*}_{11} + 58.7358\ X^{*}_{12} + 86.1350\ X^{*}_{13}$$

(0.0608) (0.1721) (17.82) (17.83)

$$+136.4550\ X^{*}_{14} + 90.8511\ X^{*}_{15} + 62.3331\ X^{*}_{16} + 79.3130\ X^{*}_{17} + 71.6848\ X^{*}_{18}$$

(17.78) (18.30) (18.25) (18.29) (18.38)

$$+54.1821\ X^{*}_{19} + 122.8085\ X^{*}_{20} - 18.1640\ X_{21} - 27.4768\ X_{22}$$

(18.33). (18.33) (18.32) (18.24)

t - (t-1) = 3 month

$R^2 = 0.91$

Standard error of $Y_1 = 31.5408$

Degrees of freedom = 61

$X_{23} = \sum_{i=1}^{n} \alpha_i X_{i\ t-1}$, the area total exogenous employment

Equation (2B)

$$Y_{1\ t} = 3016.265 + 0.2719\ X^{*}_{23\ t-1} + 3.3456\ X^{*}_{11} + 51.4569\ X^{*}_{12} + 78.7688\ X_{13}$$

(0.0534) (0.1917) (20.83) (20.88)

$$+123.0386\ x^{*}_{14} + 40.7793\ X^{*}_{15} + 67.4337\ X^{*}_{16} + 82.6051\ X_{17}$$

(20.68) (21.29) (21.27) (21.26)

$$+78.7222\ X^{*}_{18} + 59.1891\ X^{*}_{19} + 122.4779\ X^{*}_{20} + 2.0772\ X_{21} - 18.1450\ X_{22}$$

(21.28) (21.25) (21.24) (21.25) (21.21)

$X_{23} = \sum_{i=1}^{n} \varphi_i X_{i\ t-1}$

$R^2 = 0.87$

Standard error of Y=36.7231

Degrees of freedom = 61

t- (t-1) = 3 month

Table 2. A Summary of Employment Multiplier Estimating Equations 3A - 3E**

	Equation 3A		Equation 3B		Equation 3C		Equation 3D		Equation 3E	
Var.#	Coeff.	STD Error	Coeff.	STD Error	Coeff.	STD Error	Coeff.	STD Error	Coeff.	STD Error
X_1	0.0259	0.0179	0.4389*	0.1269	-0.0211	0.0112	0.2007*	0.0428	0.1104	0.0740
X_2	-0.0741	0.0518	-0.0650	0.3666	-0.0248	0.0326	-0.1095	0.1237	0.1939	0.2139
X_3	0.0661*	0.0343	0.1944	0.2429	0.0801*	0.0216	-0.0380	0.0820	-0.2389	0.1418
X_4	0.0389	0.0513	0.9808*	0.3558	0.0296	0.0316	0.7285*	0.1201	0.0230	0.2076
X_5	-0.0431	0.1156	-1.2167	0.8182	0.3157*	0.0727	0.4233	0.2762	-0.4506	0.4775
X_6	-0.0012	0.0221	-0.2989*	0.1561	0.0116	0.1386	-0.0383	0.0527	0.0302	0.0911
X_7	-0.1341	0.1200	1.2709	0.8494	0.0653	0.0754	-0.2285	0.2867	0.6788	0.4957
X_8	0.0810	0.0919	-0.0609	0.6508	-0.0213	0.0578	0.7278*	0.2197	-0.0520	0.3798
X_9	-0.0115	0.0123	0.0363	0.0871	-0.0036	0.0077	0.0212	0.0293	-0.0670	0.0507
X_{10}	-0.0011	0.0129	0.1069	0.0919	-0.0170*	0.0082	-0.0806*	0.0310	0.0165	0.0537
X_{11}	0.5128*	0.0347	0.2860	0.2455	-0.0407	0.0218	0.1837*	0.0829	2.3659*	0.1432
X_{12}	-0.0195	0.8790	15.2365*	6.2220	0.4321	0.5525	4.5018*	2.1000	8.6976*	3.6310
X_{13}	0.5124	0.8788	18.6315*	6.2210	-0.2569	0.5524	4.7535*	2.1000	13.5864*	3.6300
X_{14}	5.1196*	0.8818	27.3077*	6.2420	-0.0953	0.5542	10.3536*	2.1070	10.7818*	3.6420
X_{15}	8.9520*	0.8818	27.4307*	6.2420	0.7242	0.5542	11.0604*	2.1070	5.3181	3.6420
X_{16}	8.1498*	0.9478	31.9127*	6.7090	1.3452*	0.5957	10.3671*	2.2650	0.5951	3.9150
X_{17}	4.6545*	1.1470	32.8342*	8.1190	0.2637	0.7209	6.4615*	2.7410	13.5689*	4.7380
X_{18}	2.9402*	1.1900	30.7861*	8.4220	0.8659	0.7478	8.8952*	2.8430	20.5623*	4.9140
X_{19}	1.1113	1.1040	41.5626*	7.8150	-0.3091	0.6939	6.6663*	2.6380	12.879 *	4.5600
X_{20}	0.2816	1.0960	89.6997*	7.7570	0.2791	0.6888	2.4642	2.6180	11.7868*	4.5260
X_{21}	-0.7722	0.1069	6.9132	7.5680	0.1186	0.6720	0.0714	2.5550	2.3581	4.4160
X_{22}	-0.7057	0.9231	- 8.9811	6.5340	0.5391	0.5802	0.2227	2.2060	- 0.1610	3.8130
R^2	0.99		0.92		0.97		0.83		0.99	
STD Error of Y:	1.285		9.098		0.807		3.071		5.309	
Degrees of Freedom	52		52		52		52		52	
Constant	356.5403		1038.293		133.920		42.143		869.756	

Equation 3A: Impacts of the exogenous sectors on the local employment in finance, insurance, real estate / industries
Equation 3B: Impacts of the exogenous sectors on the local employment in wholesale & retail trade industries
Equation 3C: Impacts of the exogenous sectors on the local employment in comm., gas, electricity, & sanitary serv.
Equation 3D: Impacts of the exogenous sectors on the local employment in local transportation serv. industries
Equation 3E: Impacts of the exogenous sectors on the local employment in business & personal serv. industries

* statistically significant at an α of 0.05 level.

** For further details on the results of multiple regression and correlation analyses for the derivation of urban employment multipliers, see unpublished technical appendices of this study.

Below each estimated parameter, in parentheses, is the standard error of the estimate and the ones with an asterisk are statistically significant at an α of 0.05 level. The standard error of the estimate gives us a measure of statistical reliability.[4]

In general, the finer is the breakdown of the exogenous variables, the better is the predictive power of the model. However, an ideal theoretical model is very seldom empirically implemented mainly due to common problems faced by researchers since time immemorial--a lack of adequate quantitative data. This is no exception to this study. Particularly, the predictive power of the model may be improved by a further disaggregation of the area investment sector: the separation of housing investment from other business investments which tends to be influenced by differ ent social and institutional forces. Nevertheless, in the light of the inadequate data available, the overall breakdown of the model estimated in this study seems to be sufficient, especially in export sectors, to permit us to meas ure differential impacts of various major exogenous activities upon the area employment.

[4]The standard error of the net regression coefficients with the number of observations will serve to indicate the extent to which the values may vary from the true value simply due to chance of fluctuations of sampling, and so caution him not to attach more importance to them than their significance justifies.

Various time lags, ranging from one to six months, were experimented with to select the best empirical fit of the export-local employment relationship. The selective criteria for the best fit were established in terms of the degrees of statistical significance of the net regression coefficients in the equations estimated (indicated by T-test), and the determinant of multiple correlation (R^2), which accounts for the proportion of variance in the dependent variable associated jointly with the independent variables. On the basis of the above criteria, a three-month time lag was considered as yielding the best results out of the six different time lags tested. Therefore, a three-month time lag between the exogenous and endogenous employment was incorporated into the implementation of the empirical model in this study.

The equation (1) is a disaggregated model designed to measure differential impacts of major export sectors and the investment sector in the St. Louis SMSA upon the area total local employment. More specifically stated, the net regression coefficients represent the extent to which the area local employment would expand (or decrease) as a result of multiplier effects of the initial increase (or decrement) in the sectors for which the net regression coefficients were computed. For instance, the net regression coefficient for aircraft and parts industries (0.8256, significant at

an α of 0.05 with T-test of 2.58321) as it stands indicates that the area local employment tended to increase about 83 persons for every increase of one hundred employees in the above industries on the average, under the ceteris paribus condition. Therefore, the employment multiplier for the aircraft and parts industries corresponds to 1.83, which is computed by dividing changes in the total area employment by changes in export employment in the industry under consideration.

The multiplier value obtained may differ from one sector to another because of many interindustry differences in the following respects: (1) the industry purchase of input factors from local sources; (2) wage and productivity; and (3) consumption patterns of employees. The last two items account for the interindustry difference in the income-induced effects, while the first represents the interindustry effects. For instance, a substantial difference in the multiplier values estimated between chemicals and allied products industries (1.13) and electrical machinery industries (3.71) may be explained partly in terms of the difference in the amount of the industry purchase of inputs from local sectors. According to the 1955 St. Louis input-output matrix, the chemicals and allied products industries purchased locally inputs in the amount of $244,075.00 out of the total inputs purchases estimated at $494,752.00.

Therefore, about the half of the total inputs purchases in dollar values was from local sources and the other half constituted imports from outside the St. Louis SMSA. The local purchases of inputs by the electrical machinery industries amounted to $137,931.00 as compared with $202,970.00 worth of the total inputs purchases. Thus, about 70 percent of the total input purchases came from inside the St. Louis SMSA and the rest represented import leakages.[5]

Nearly all the signs of the regression coefficients in the equation are in accordance with the theoretical expectations. However, the two coefficients with a negative sign require comment. First of all, the two coefficients, X_6 (federal and state governments = -0.0383) and X_{10} (miscellaneous industries = -0.3756), are statistically insignificant at an α of 0.05. Therefore, little reliabilit can be placed on these estimates. Secondly, little economic importance can be attached to them. The magnitude of the coefficient for X_6 is so small that the area local employment can hardly be affected by changes in the activity level of this sector. With regard to the miscellaneous industries, largely due to the average-out effect of the aggregation of heterogeneous sectors, it is extremely difficult to

[5]John C. Bollen, op. cit., Supplement to Chapter 16, Appendix F., pp. 460-471.

differentiate between component industries having positive multiplier effects and those having negative effects. Thirdly, it is theoretically conceivable to have a negative multiplier sign. An increase in demand for products of an export industry whose income-induced and interindustry effects are relatively low may reduce the demand for products of other export industries with a relatively high degree of multiplier effects, when their products are closely substitutible. This shift of demand may occur through a price cut or change in taste in favor of the former or in any other way. Then, an employment expansion in such an export industry would be associated with a decline in the area local employment, because a net gain of the area local employment attributable to an initial employment increase in the former industry can be more than offset by a net loss of the same employment resulting from a decline in other export activities.

X_{11} is a trend variable, which indicates a tendency for the area employment to increase (or decrease) over a long period of time.[6] X_{12}-X_{22} are dummy variables designed

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[6]The long run gradual growth or decline of certain economic activities implied in trend may result from such fundamental forces as population growth, technological changes, improvement in productivity, and changes in consumption habits.

for seasonal adjustments,[7] which reflect the recurrence of the monthly pattern of variations in the area employment. Most seasonal variations in the area employment tend to increase in the positive direction, and their magnitudes range from the lowest value of -24.7 to the highest value of 123.8.

The seasonal adjustments improved substantially the regression fit by increasing the value of R^2 from 0.78 for the fit seasonally unadjusted to 0.96 for the fit seasonally adjusted. Moreover, as a result of the seasonal adjustment, the number of regression coefficients which are statistically significant at an α of 0.05 doubled. Standard errors of most regression coefficients were considerably reduced, as evidenced by the fact that out of a total of 11 independent variables, eight variables had T-test values greater than 1.3 when seasonally adjusted, as compared with only three variables exceeding this value for the equation without seasonal adjustments.

Often, the proper treatment of seasonal factors would improve considerably an empirical measurement of economic relationships. This is particularly likely to be true in such a short run analysis dealing with monthly variations as this study, since underlying factors tend to move slowly

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[7] Seasonal or periodic variations may be explained by the operation of forces related to climate or custom.

from month to month or even from quarter to quarter, and seasonal variations may dominate the short run changes in observed data. In short, movements in observed data may fail to reflect changes in basic economic conditions, when they are not free of purely seasonal factors.

Finally, the determinant of multiple correlation (R^2) in the equation (1) indicates that all 22 variables together explained 96 percent of all the variance in the area total local employment observed during this 75-month period.

The same interpretations as applied to the equation (1) can be followed in case of the equations (3) except for the difference in the dependent variable. In the equations (3), the total local employment in each major component of the area endogenous sectors $[(1-\alpha_i)X_i]$ was substituted for the area total local (endogenous) employment ($\sum_{i=1}^{n} (1-\alpha_i)\ X_i$) as the dependent variable. These equations were designed primarily to analyze the relative importance of the area major export industries in terms of the employment impacts upon individual consumption and services industries selected.

It is interesting to note that variations in the area local employment associated with seasonal elements are markedly high in the retail and wholesale trade industries among various area consumption and service

industries. Among major export industries in the area, electrical machinery ($X_4 = 0.9808$) and aircraft and parts ($X_1 = 0.4389$) appear to have most significant employment multiplier effects on the retail and wholesale trade sector. Probably, relatively high wage rates in these two industries may have some important bearings on high multiplier effects, since the income-induced effects are expected to work most effectively in the retail and wholesale trade sector.

The equations (2) attempt to derive an aggregate multiplier for the entire exogeneous sectors combined. In the equation (2A), as mentioned before, only direct export employment coefficients (α_i) were used to divide each industry employment into the export and local employment, and they were respectively aggregated into one variable, exogenous and endogenous. The multiplier value obtained through the regression of the exogenous employment upon the endogenous employment was affected by both interindustr, effects and income-induced effects. In contrast, direct and indirect export employment coefficients ($\varphi_i = \alpha_i + \alpha_i''$, α_i''= export-linked employment coefficients computed from the inverse matrix)[8] were employed for the same procedure in the equation (2B), and hence, its multiplier value is determined only by

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[8]See pp. 25-26.

the income-induced effects. Consequently, the discrepancy between the two regression coefficients of the two equations would indicate the relative importance of the inter-industry effects with regard to the area employment creation. The difference between the two parameters estimated (0.4785 for the equation (2A) - 0.2719 for the equation (2B)) is 0.2039. Therefore, it can be inferred from this that on the average, there is an increase of about 48 persons in the local employment for every one hundred increase in the exogenous employment (multiplier = 1.48). Slightly less than the half of this employment increase (20/48 = 0.42) is due to the inter-industry effects, and the remainder (58%) is accounted for by the income-induced effects.[9]

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[9]The two regression coefficients are highly significant at an α of 0.01 level with T-test values of 7.8297 for the equation (2A) and 5.0922 for the equation (2B).

Most previous studies concerned with an application of the employment multiplier to the study of a regional economy have the two common characteristics: (1) the use of location quotients or a variation of them for the classification of industry employment into the export and local components, and (2) the derivation of an aggregate multiplier for the entire export sector by a simple linear regression of total local employment on total export employment. For example, see G. E. Thompson, op. cit., pp. 61-67; George H. Hildebrand and Arthur Mace, op. cit., pp. 241-49; and Kyoshei Sasaki, "Military Expenditures and Employment Multiplier in Hawaii," Review of Economics and Statistics, vol. 45. (August, 1963), pp. 298-304. The regression coefficient for X_{23} in the equation (2A) also represents

This aggregate multiplier can be used (1) to calculate an optimal rate of employment growth required to sustain full employment in the area economy, and (2) to project population growth for a given level of employment increment in the exogenous sector. At the outset, it must be admitted that the method used here to project future population and estimate an optimal rate of employment growth is very naive and crude. However, the following example is not intended for the demonstration of a sophisticated technique to estimate the probable magnitude of such variables, but for an illustration of how an urban

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an aggregate multiplier for the exogenous sectors as a whole. However, it differs from most previous studies in the form of equation estimated and the method used to classify export and local employment. The equation (2A) takes the form of multiple regression designed to allow for trend and seasonal elements in time series data, with which most studies were not usually concerned. In addition, this study relied upon the information on export as percent of the total sales by industry, obtained through the direct survey method for the preparation of the 1955 St. Louis input-output table.

The value of employment multiplier (1.475) estimated from the equation (2A) is considerably lower than those obtained from the previous studies cited above. The value of employment multiplier in Lancaster County, Nebraska was estimated to be 2.311, while that of Los Angeles County was 2.248. The employment multiplier for the Hawaii study was 2.283. The difference in the multiplier values obtained between this study and others may arise from the following sources: (1) difference in the method used to classify industry employment into export and local parts; (2) difference in the form of equation specified; (3) probable effects of trend and seasonal adjustments on the multiplier value; and (4) interregional difference in the economic environment.

employment multiplier analysis can be applied to various important problems of our time.

First, a set of assumptions has to be made with regard to the desirable state of economy we wish to achieve. Let us assume that five percent unemployment of the labor force is the level which maximizes the area employment without risking inflation, an annual rate of population growth 10,000, and the labor force participation rate 45 percent. Then, an annual growth rate of the labor force is 4,500 (10,000 x .45) and 4,275 (4,500 x 0.95) additional jobs are required each year to maintain a full employment economy at the five percent level. The multiplier estimate (1.48) suggests a required annual expansion of about 2,889 exogenous employment (4275/1.48 = 2889) to meet an annual increase of 4275 total area employment. To the extent that there is an appreciable increase of employment associated with trend and seasonal factors, the above requirement for the expansion of exogenous employment has to be discounted.

In the above illustration, population growth is given or rather a determinant of a required growth rate of exogenous employment to maintain full employment. This time, population growth can be treated as a determined variable and exogenous employment as a determinant of the former. Under the same set of assumptions specified

for the previous example, an annual increase of 3,000 exogenous employment will show a rise in population of about 10,311 (3,000 x 1.48 / .45 x .95) each year.. The first method may prove useful in planning full employment in a rapidly growing region such as California in terms of population due to a heavy influx of migration. The application of the second method may be relevant to a region characterized by a stagnant or stable population growth. In such a region, the multiplier analysis would be useful in estimating various future needs (such as water resources needs, school expansion, capital improvement, public transportation, etc.) associated with an anticipated population growth resulting from the introduction of a new export industry or expansion of the existing industries.

Finally, it is interesting to verify empirically the theoretical expectation that the magnitude of R^2 for the disaggregated model (0.96) should be greater than that of the aggregated model (0.91), since the average-out effects involved in the aggregation tend to reduce the explained variance.[10]

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[10]Mathematically expressed:

$$\sum_{i=1}^{n}[Y_i - a(x_{i1}+x_{i2}+ \ldots +x_{ik})]^2 \geq \sum_{i=1}^{n}[Y_i - (a_1x_{i1}+a_2x_{i2}+ \ldots +a_kx_{ik})]^2$$

E. A Test of Autocorrelated Disturbances

Before applying a test of autocorrelation to the residuals, it would be worthwhile to examine briefly the consequences of autocorrelated disturbances upon the regression analysis. One of the crucial assumptions of the linear regression model is the serial independence of residuals about the regression line.[1] More rigorously stated, the serial independence of the disturbance term can be expressed in the matrix notation as follows:

$$E(u\,u') = I$$

$$E(u_t\, u_{t+s}) = 0 \text{ for all } t \text{ and for all } s \neq 0,$$

where u is an n x 1 column vector, u' a row vector and

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[1]The assumptions crucial for the regression estimation are:

(1) $E(u_i) = 0$ for all i, implying that the u_i are random variables with zero expectation;

(2) u_i have constant variance σ^2, referred as homoscedasticity;

(3) $E(u_t u_{t+s}) = 0$, which implies the serial independence;

(4) X is a set of fixed numbers, which postulates the conditional distribution of Y for given X. In other words, for every possible combination of values of the independent variables, there exists an expected value $E(Y/X_{1i}, X_{2i}, \ldots, X_{ni})$, which may be regarded as the arithmetic mean of all possible values of Y given that particular set of values of the independent variables. The individual values of Y for the given combination of X's will show only random deviations about the expected value;

(5) X has rank k n, requiring that the number of observations exceeds the number of parameters to be estimated. For further detailed treatments of the subject matter, see J. Johnston, Econometric Methods (New York: McGraw Hill, 1960), p. 107-

the product u u' is a symmetric of order n. It implies the independence of disturbances from the previous values.[2]

In the regression model involving time series observations, two or more successive residuals may be influenced by common factors rather than by completely independent (random) ones. Serial correlation in the residuals may arise from many sources such as (1) the incorrect specification of the form of the relationship between the variables; (2) the omission of important variables; (3) measurement error in the "explained" variable.[3]

If we fit a regression line to a set of observations which are autocorrelated, estimates α and β obtained are still unbiased. However, the conventional least-squares error formula cannot be applied to estimates derived from the serially correlated data. In particular, the sampling variances of the regression coefficients will be seriously underestimated. Furthermore, the estimates of σ_u^2 from an autocorrelated series tend to be biased downward. Moreover, predictions obtained from such series are likely to be inefficient, i.e., predictions with needlessly large sampling variances.[4]

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[2]*Ibid.*, p. 177.

[3]*Ibid.*, pp. 177-178.

[4]For various mathematical proofs on the inapplica-

Finally, time series regression analysis may be philosophically objectionable on the ground that any sequence of observations at successive intervals are not drawn from the precisely same universe. However, in some cases, universes or underlying conditions undergo changes so slowly or to such an imperceptible degree that they are too trivial to exert significant effects upon the regression coefficients between different variables in universes. This would be the case in poin., especially when we are dealing with the situation covering a short span of time. Even in case of some perceptible changes in universes, our thorough examination of the subject matter would provide us with the knowledge of the probable magnitude of changes in universes over a given period of time. For instance, if changes in the universe proceed in certain regular or predictable manner such as a steady rate of progression, they can be sometimes allowed for by trend and seasonal factors, progressive shifts of regression slopes, and so on. Therefore, the above argument strongly emphasizes the need for a careful examination of given time series data with regard to the

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bility of the conventional least-squares error formula to the autocorrelated series, see J. Johnston, op. cit., chapter 7, pp. 177-200.

possible requirement of seasonal and trend adjustments prior to the regression analysis, and for a test of auto correlation in the residuals from a fitted equation.

In view of the possibly serious consequences resulting from applying least squares methods to time series data containing autocorrelated terms, the Durbin-Watson d statistic test for the presence of autocorrelation in residuals was implemented.

The Durbin-Watson d statistic test is defined as:

$$d = \frac{\sum_{t=2}^{n} (Z_t - Z_{t-1})^2}{\sum_{t=1}^{n} Z_t^2}$$

where Z_t ($t = 1, \ldots, n$) are the residuals from a fitted regression equation.

Exact significance levels for d are not known, but lower and upper bounds d_L and d_U for various values of n (sample size) and k (number of independent variables) have been tabulated by Durbin and Watson. If $d < d_L$, positive autocorrelation is presumed to be present. If $d > d_U$, accept the hypothesis of random disturbances. If $d_L < d < d_U$, the test is inconclusive and alternative tests may be required.[15]

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[15] J. Durbin and G. S. Watson, "Testing for Serial Correlation in Least Squares Regression," parts I and II, <u>Biometrika</u>, 1950 and 1951.

The computed value of the Durbin-Watson d statistic was:[16]

$$d \quad \frac{\sum_{t=2}^{75} (Z_t - Z_{t-1})^2}{\sum_{t=1}^{75} Z_t^2} = \frac{47112}{28632} = 1.6454.$$

The Durbin-Watson tables do not extend as many as 22 explanatory variables, but d_L and d_U for $k = 5$ and $n = 75$ are respectively 1.49 and 1.77 at 5% significance point; and 1.34 and 1.62 at 1% significance point. Therefore, the test is most likely to be inconclusive at 5% significance level, and even at 1% significance level, since the limits get wider as the number of independent variables increases.

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[16]See unpublished technical appendices of this study for a detailed account of the computational procedure.

CHAPTER V

THE EMPLOYMENT IMPACT OF THE AEROSPACE INDUSTRY

Since we plunged into the Space Age immediately after the end of World War II, broad technological, social and economic impacts inherent in the vast aerospace research and development program have been felt in every facet of our life in varying degrees of intensity. Often, their effects are quite visible as in the case of the invention of new products, experimental weather and communication satellites, and improved industrial processes. Not infrequently, they take the intangible form of the enhancement of political prestige and the satisfaction of man's urge to explore the unknown. The diversity of their impacts is virtually unlimited in scope. For instance, in the field of research and development, the NASA and Defense Department research spending may accentuate the general trend of U. S. research efforts toward scientific technology and of growing financial linkages between our major universities and the Federal Government. The aerospace program may have an important bearing on the interregional differentials in the rates of economic growth. The entire aerospace program may increase

the relative proportion of national resources allocated to the government sector. Thus, the Federal Government may exert greater influence on business fluctuations in our economy. These are only a small part of the whole story. The description of broad impacts of the aerospace programs even in the most superficial manner is beyond the scope of this study. As stated explicitly before, the scope of this study is limited to one important aspect of such broad impacts, i.e., employment impact of the aerospace activities on a regional economy.

In the St. Louis SMSA economy, McDonnell Aircraft Corporation alone represents nearly all production of aircraft and other aerospace products. McDonnell is the largest single employer in the State of Missouri. The company recorded, as of December, 1963, 34,851 employees who were engaged primarily in the production of Phantom aircraft for the Armed Forces and Gemini spacecraft for NASA. The importance of the company to the area economy is evidenced by its relative size. McDonnell Aircraft has more than 13 percent of the 261,500 employed in the manufacturing industries and 4.2 percent of the 837,000 total employed in the area in 1963. Moreover, according to the St. Louis Post-Dispatch, McDonnell accounted for most of employment gains in the area in 1962 and 1963. The company's net employment

gains amounted to 8583 in 1963, with receipts of more than one billion dollars, while the total number of jobs in the area increased 14,200 in the same year. What is more economically important is that nearly all of the McDonnell employees work in the area.[1]

This favorable trend is expected to continue in the years immediately ahead, judging from the recent backlog rises. As a result of the two major programs mentioned above and others, the company's backlog was reported to have surpassed one billion dollars as of March 30, 1963, and amounted to $951,107,297 as of September 30, 1963, as compared with $294,921,558 on September 30, 1962. The contract for the Phantom under the Government's fiscal budget in 1964 is expected to exceed the $625,000,000 for fiscal 1963. The Air Force plans to purchase more than 2000 Phantoms at a cost of more than $5 billion under a program extending through 1968.[2]

Another measure of the phenomenal growth of the company is provided by a substantial increase in the company's capital expenditure. Expenditures for facilities in the two years ending in June 30, 1963 amounted to about $45,000,000. The company spent $20,413,160 on new plant and equipment outlays in fiscal year 1963. They are

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[1]Business and Finance Section, "Annual Review and Forecast," The St. Louis Post-Dispatch, January 5, 1964.

[2]Fortune, November, 1964, p. 139.

expected to be about $24,000,000 in fiscal 1964.[3]

However, the important role the aerospace industry plays in the area economy extends far beyond the sheer magnitude of direct employment of a given number of people contributed by the industry. The aerospace industry exerts discernible effects on the area local employment through the multiplier process of income propagation. It is precisely the estimation of these multiplier effects that poses many difficulties due to the highly interdependent nature of modern economic activities. It is certainly important for city planners and others interested in area economic growth to have a means of estimating these indirect employment effects. Such an estimate will enable us to form informed judgments concerning such matters as prospects for labor force and population growth, social and business capital requirements, the growth of the tax base, land use patterns, and so on. Furthermore, in a period of deep involvement by the Federal Government in the nation's economic activities, the measurement of such indirect effects would prove highly useful in assessing the impact of a partial reduction or complete withdrawal of the government contracts upon a regional economy. Thus, this will serve the purpose of determining the vulnerability of the area economy

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[3]The St. Louis Post-Dispatch, loc. cit.

to any unexpected political decision, as well as of providing a basis for planning the alternative course of industrial growth, which is less sensitive to the cyclical fluctuations of the nation or highly unpredictable events.

In the theoretical model developed in Chapter III, the variables were dichotomized into exogenous and endogenous elements. The nature of the functional relationship specified between these two categories of variables is basically a conditional prediction. That is, the value of the endogenous variable (also called predicted variable) is conditional upon a given set of values selected for the exogenous variables (also called predictors). The different assumptions about the probable changes of predictors would yield a wide variety of values of the predicted variable. Therefore, it is often necessary for planners not only to determine the form of a relationship between a given set of endogenous and exogenous variables, but also to predict the probable changes in the exogenous sectors.

Unfortunately, predictable behavior pattern is not likely to be observed in most exogenous variables, due to highly unstable elements inherent in the properties of such variables. Prediction on the future events exogenous to the area economy may call for an integrated study approach of the subject matter, which covers various academic disciplines

beyond the traditional boundary of economics.

The space program is a case in point. Forecasting expenditures for the space program is extremely difficult and hazardous, simply because they are to a large extent determined by political considerations. Perhaps Mr. Anthony Down most clearly summed up this difficulty with the following statement:

> . . . We are immediately face to face with the problem that no one really knows how much the program is going to cost us. There is too much uncertainty in forecasting budgets for research and development programs of this type. . . . Forecasting future budgets is extremely difficult because of what Secretary McNamara has called the "bow-wave" effect. Presently known programs call for a buildup of expenditures over the next couple of years and then a gradual decline beyond that. But as you move ahead, new programs arise, and the need for "just a few more billion" to finish off existing programs keeps moving ahead along with you like the wave ahead of the bow of a ship as it moves through the water. Moreover, experience shows that most government development programs actually cost much more than the initial estimates for them, sometimes double or triple or more.[4]

Similar difficulties would be encountered in predictin expenditures for military aircraft as exemplified in the

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[4]Anthony Down, "The Economic Effects of the Space Program," Conference on Space-Age Planning NASA SP-40, Chicago, Illinois, May 6-9, 1963, p. 153.

case of uncertainty arising from the Pentagon's possible move toward fewer kinds of military aircraft and fewer larger-quantity orders.[5]

In light of the uncertainty which surrounds any prediction of future employment variations in the aerospace industry, a simple trend projection was employed. Employment growth in the aerospace industry was taken as the dependent variable and time as the independent variable, and a simple linear regression was fitted to the data. Based on the monthly employment data for the St. Louis SMSA for the period of January 1958 to June 1964, the equation of the regression line is

$$Y = 224.80 + \underset{(0.183)}{0.817}\, X$$

where Y and X represent, respectively, employment growth in hundreds and the trend, and the number in parenthesis the standard error of the regression coefficient. The regression coefficient is statistically significant at an α of 0.01. The equation can be summarized as follows:

regression coefficient = 0.817

standard error of regression coefficient = 0.183

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[5] *Fortune*, Nov., 1964, p. 137.

T test = 4.4624

R = 0.456

standard error of Y = 36.413

degrees of freedom = 76

the .95 confidence interval for the regression coefficient would extend between 1.094 and 0.540 or 0.817 ± 0.277. The equation indicates that based on the past trend, there has been a tendency for monthly increase of about eighty employed in the aerospace industry on the average, and this would amount to an annual increment of about 900 - 1,000 employees.

No doubt a trend projection of this type is far from being satisfactory, and should be regarded rather as a most hypothetical exercise. The most serious limitation of this procedure is the assumption that relationships or trends which have existed in the past will continue to exist in the future and with the same intensity. In addition, this regression line has no upper limit. It implies that employment will grow indefinitely in the future and approach an infinite size. However, the relevance of the second criticism to this study should not be taken too seriously, since any projection to be made in this study is short run in nature. Despite severe limitations, the trend projection method was adopted in preference to wild

guessing, especially in the absence of a proper technique for prediction of changes in the exogenous sectors, and data to implement it. Finally, it must be borne in mind that like most multiplier analyses, the application of this study should be a conditional prediction, i.e., prediction of the area employment for a given level of employment changes in the aerospace industry under <u>ceteris paribus</u> conditions. Therefore, the problem of predicting changes exogenous to the model was explicitly assumed away.

The net regression coefficient of 0.825 for the aerospace industry in the equation (1)[6] indicates that for a given employment change in the above industry, the area local employment tended to change by 0.825 times that amount; or for every change in employment of 100 in the aerospace industry, a change in the area local employment of 83 in the same direction is likely to occur. This would be approximately equivalent to a multiplier value of 1.83, since the ratio of the net change in the total area employment to the employment change in the aerospace industry, everything else held constant, is 1.83 (183/100 = 1.83).

A substantial number of people employed in the aerospace industry are engineers, scientists, administrators,

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[6] See p. 45.

and other highly trained personnel. Relatively less unskilled and semi-skilled workers are found in the aerospace industry as compared with other manufacturing industries. They are exceptionally well-paid individuals, and their average wage levels are substantially above those in other manufacturing industries. McDonnell payrolls totalled more than $4,500,000 a week in 1963 and this is roughly equivalent to an average of $130.00 a week per employee (4,500,000/35,000 as compared with a weekly average rate of $107.00 in other manufacturing industries in the same period.[7] In view of a positive relationship between a high wage rate and the income-induced effect, one could expect the multiplier value for the aerospace industry (1.83) to be higher than the one obtained here, when this value is compared with others such as electrical machinery (3.71) and primary metals (1.85). However, a higher wage rate would not necessarily generate a higher income-induced effect. All depends upon the consumption pattern of the income recipients in the industry in question. It is a commonly accepted hypothesis that the higher the income, the greater proportion of income saved, i.e., the lower marginal propensity to spend. In addition, the incidence of import leakages, whether it takes the form of consumption of luxury items or spending

[7]The St. Louis Post-Dispatch, January 5, 1964, loc. cit.

outside the economic area on vacation, is expected to be higher in upper income brackets than in the lower income groups. Perhaps, the most important contributing factor in minimizing the multiplier effects of the aerospace program would be a relatively low level of the inter-industry effects, i.e., purchases of productive factors from local sources. Although the original amount of the total prime contracts for the fiscal 1964 was unknown, it was reported that McDonnell Aircraft subcontracted total purchases of $508,792,020 as of September,1964, and out of this total, $194,169,514 (38.2%) went to California, $27,285,397 (5.4%) to Missouri, and $9,089,297 (1.8%) to Illinois.[8] Less than 6 percent of the total subcontracts remained in Missouri, and probably even less in the St.Louis SMSA. If the percentage of the total subcontracts remaining in the area had been larger, a higher level of the area income and employment gains accounted for by the aerospace program might have been shown in this study.

The similar interpretations can be applied to the equations (3), which were primarily designed to measure differential employment impacts of the exogenous sectors upon the area major consumption and service industries

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[8]<u>The St. Louis Post-Dispatch</u>, Business and Finance Section, September 29, 1964.

selected. Again, on the assumption that the causal circumstances of the observation period continue to prevail, employment multipliers for the aerospace industry were derived with respect to each of the following area consumption and service industries selected:

1.0259	for finance, insurance, and real estate
1.4389	for wholesale and retail trade*
-1.0211	for communication, gas, electricity, and sanitary service
1.2007	for local transportation services*
1.1104	for business and personal services

(the asterisk indicates the statistical significance of a coefficient at an α of 0.05)

The employment multiplier effects of the aerospace program seem to be negligible in finance, insurance, and real estate industries; and communication, gas, electricity and sanitary service industries. But little reliability can be placed upon these estimates, since they are statistically insignificant. Among the area consumption sectors, the wholesale and retail industries seem to be most responsive in their adaptation of employment to changes in the volume of employment in the aerospace industry. This result appears to be logical, for the income-induced effects tend to work most effectively in retail and wholesale sector.

If we assume an annual rate of employment increase of about 1,000 in the aerospace industry in the next couple of

years, as extrapolated from the past trend, the area local employment would show an annual net gain of about 826 (0.826 x 1,000), and the total area employment 1,826 attributable to expansion in the industry.

However, an annual increase of 1,000 employment extrapolated from the least squares trend fit appears to be considerably smaller than any estimate one can obtain on the basis of recent production data available for the aerospace program in St. Louis. In 1963, McDonnell employment statistics showed a net gain of 8,583 employment. In fiscal 1964, McDonnell's earnings rose 44 percent over those of the previous fiscal year. Throughout the first quarter of fiscal 1965, the company's sales and earnings increased about 25 percent over the first quarter of fiscal 1964. All favorable factors seem to indicate the fact that McDonnell is reasonably assured of further phenomenal increases in its sales and earnings during the next three years. Such factors are a current backlog of more than a billion dollars with a schedule of output of more than 500 Phantoms next year, the Pentagon's plan to buy some 2,000 Phantoms at a cost of more than $5 billion for the period of 1964-68, and a recent $457 million contract witn NASA for the production of Gemini spacecraft.[9] Under these

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[9] Fortune, November, 1964, p. 137.

circumstances, it would be reasonable to expect that percent increases in the company's earnings and sales in fiscal 1965 and 1966 would be no less than those recorded in fiscal 1964. Since employment changes tend to move in the same direction with sales and earnings changes, an annual average increase of about 5,000 employees in the aerospace industry for the next two years may be rather a conservative estimate, specially as compared with an actual net employment increase of 8,583 in 1963. If this estimate is assumed to prevail for a period extending through 1967, the area local employment would increase by about 4,000 (5,000 x 0.83) and the total area employment by 9,000 due to the aerospace program in St. Louis each year.

The employment multiplier analysis would seem to be of some usefulness in measuring the probable magnitude of adverse effects of disarmament or of a partial reduction of government contracts on a regional economy. For instance, if we assume a hypothetical case of a partial contraction of the government contracts which necessitates a 10 percent cutback of employment in the aerospace industry, the area economy would suffer immediately a direct loss of 3,500 (35,000 x 0.1) employed in the aerospace industry.[10] In addition, about 2,900 (3,500 x 0.83 = 2,900)

[10]There is no real reason for specifying a level of

employed in various consumption and service industries would lose their employment in due course of time through the multiplier effects of the reduced government contracts. If it were not for a small volume of subcontracts undertaken inside the St. Louis SMSA, thus minimizing export-linkage effects, the repercussion on the area economy would be expected to be greater.[11]

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reduction of the government contracts requiring a 10 percent curtailment of employment in the aerospace industry in St. Louis. This figure was used mainly because of computational convenience. Any level of curtailment in expenditures for the aerospace program can be selected for the impact study of the aerospace industry, if some justification can be established for such a choice, whether on the basis of empirical evidence or informed judgment. However, it must be cautioned that the multipliers may not be applicable to an impact analysis of such drastic changes as the total elimination of the aerospace program in St. Louis, since the multipliers seem to hold for marginal changes.

[11]In the real world, any reduction of government contracts is most likely to be accompanied by various offset programs such as reduction of business and personal taxation, public capital improvement, urban renewal and slum clearance, regional resource development. Isard and Schooler concluded tentatively from their study on local and regional impacts of reduction of military expenditures that adverse effects resulting from such reductions would be virtually insignificant in terms of income, output, and employment, if proper offset programs and reconversion of facilities and manpower used for military production are instituted. Their study was concerned with possible impacts upon six regions of the United States including the St. Louis SMSA. The study focused upon the use of regional input-output models. They used the 1955 St. Louis input-output study, particularly the inverse matrix, for the impact analysis for the St. Louis SMSA.

As a final analysis, it must be reemphasized that the application of this study should necessarily be short run. In the long run analysis, one must incorporate into a framework other independent factors such as the propensity to consume, changes in taste, population shifts, the tax structure, and technological changes. Some of the independent factors cited above tend to change so slowly that their influence would be expected to remain reasonably insignificant in the short run. This is particularly

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The total (direct, indirect and induced) reduction in income and employment associated with the effects of a 10 percent ($25.6 million) across-the-board reduction in military contracts were $16.9 million and 3261 respectively.

They assumed a hypothetical offset program in the form of reduction in personal income taxation which raises the area disposable income to a level equal to its prorated share of $2.1 billion increase in U. S. total disposable income in 1959. In such a case, the increase in total gross output, income and employment would have been $50.3 million, $15.0 million and 3651. A reduction of military contracts for aircraft production by $25.6 million would have resulted in the overall decrease of $56.7 million in gross output. It must be cautioned that these findings are highly tentative and tenuous, since the 1955 input-output table was used without being redesigned or updated to serve the specific purposes of this impact analysis. For further details on the results of the study for other five regions as well as the St. Louis SMSA, see Walter Isard and Eugene W. Schooler, An Economic Analysis of Local and Regional Impacts of Reduction of Military Expenditures, a paper presented at the Peace Research Conference at University of Chicago, November 18-19, 1963 (mimeographed). Similar conclusions were drawn from a recent study by Leontief and Hoffenberg on the national impacts of a reduction in military expenditures. For further information on this study, see Wassily W. Leontief and Marvin Hoffenberg, "The Economic Effects of Disarmament," Scientific American, vol. 204 (April, 1961), pp. 47-55.

true in case of population shifts, changes in the consumers' taste, and the propensity to consume. Finally, it is hoped that current data obstacles for these variables will be removed so that it becomes possible to carry out a comprehensive multiplier analysis aimed at the formulation of a long run regional planning.

CHAPTER VI

SUMMARY AND CONCLUSIONS

The multiplier theory has been applied extensively to a great variety of problems in economics for the past several decades by such outstanding economists as Kahn, Keynes, Clark, Metzler, Machlup, and many others. The Urban employment multiplier analysis is an extended application of foreign trade multiplier among many different types of multipliers. The scope of urban employment multiplier analysis is limited to an examination of the total employment effects of changes in employment in export and investment sectors.

The major purpose of this study was to measure differential employment impacts on the St. Louis area economy resulting from variations in the activity levels of the area export and investment sectors for the period of January 1958 to June 1964.

Among important findings of this study was an empirical verification of theoretical relationships postulated between endogenous and exogenous employment, as indicated partly by a highly significant determinant of multiple correlation (0.96). Empirical findings were consistent

with the employment multiplier hypothesis which states that an employment increase in the exogenous sector will increase the total area employment by an amount greater than the initial increment, and thus the employment multiplier value is greater than 1.00. More specifically stated, in accordance with the above theoretical expectations, nearly all the signs of the regression coefficients for the export and investment sectors were positive.

The relative strength of the employment impact on the area economy varied substantially from sector to sector, mainly due to interindustry differences in the income-induced effects and interindustry effects. The statistically significant net regression coefficients were: 0.8256 for aircraft and parts, 2.7112 for electrical machinery, 0.4324 for the area investment sector, 2.158 for machinery (except electrical), 4.4176 for trend, and most of 11 seasonal variables whose values ranged from -22.6701 to 123.7589.

As a result of the seasonal adjustments, the regression fits were substantially improved in terms of R^2 and standard errors of the net regression coefficients. Variations in the local employment associated with seasonal factors were highest in retail and wholesale trade among various consumption and service industries in the area.

The length of a time lag assumed between exogenous and endogenous employment had significant effects on the multiplier values derived. Among the six different time lags tested, a three month time lag yielded the best empirical fit.

The aggregate multiplier analysis enabled us to measure, though highly tentative, the relative importance of the income-induced effects vs. the interindustry effects; slightly less than half of the area employment increase (42 percent) was due to the interindustry effects, and the remainder (58 percent) was accounted for by the income-induced effects.

In the light of the possibly serious consequences resulting from applying least squares to time series data containing autocorrelated terms, the Durbin-Watson d statistic test was conducted. The test was inconclusive at five and one percent significance levels.

A part of the emphasis of this study was focused on the employment impact of the aerospace program on the area economy. The measurement of multiplier effects resulting from the aerospace program has some important implications in a time of deep involvement by the Federal Government in the nation's economic activities. The knowledge of probable magnitudes of such multiplier effects would make it possible to plan and cope effectively with various economic impacts

on a region arising from variations in the Government contracts.

The importance of the aerospace industry to the St. Louis area economy can be readily noted by the fact that it is the largest single employer in Missouri with about 35,000 employees. Moreover, the industry contributed the highest job gains in the St. Louis area, accounting for more than half of the area total employment increases in the past couple of years.

A short run projection of employment on the basis of the least squares trend fit (January 1958 - June 1964) indicates a monthly increase of about 80 employees and an annual expansion of 900 - 1,000 employees in the aerospace industry.

The multiplier analysis for the aerospace industry (with the net regression coefficient of 0.826) indicated that if a projected annual rate of employment increase of about 1,000 in the aerospace industry is assumed to prevail in the next couple of years, the area local employment would show a net gain of about 826 and the total employment 1,826 each year due to an annual employment increase in the aerospace industry. If this multiplier is applied to a hypothetical case of a partial reduction of the government contracts which necessitates a 10 percent cutback of

employment in the aerospace industry, the area economy would suffer a loss of 3,500 jobs in the industry, and a reduction of additional 2,900 employment in various consumption and service industries in the area.

The multiplier effects of the aerospace industry appear to work largely through the income-induced effects, and the relative strength of the interindustry effects seems to be insignificant. Considerably high wage rates in the industry relative to those in other manufacturing industries and a relatively small volume of aerospace subcontracts remaining inside the St. Louis SMSA seem to support the above statement.

One of the substantive though tentative implications drawn from major findings of this study is that the model used here offers appreciable improvements in a number of respects over most economic base studies previously completed.

First of all, most economic base studies concerned with the application of employment multiplier analysis to a regional economy used one of the two common methods (except for the input-output approach): (1) the simple regression of changes in the total local employment on changes in the total export employment; (2) a simple computation of a "basic-service" ratio, i.e., the ratio between the total export employment and the total local employment at a given

point of time. Thus, multipliers estimated in the previous studies were largely aggregate multipliers for the entire export industries. This study would probably represent one of the few economic base studies, if any, to use a disaggregated model intended to measure differential impacts of each major export and investment sector on the area local employment, using time series data.

Empirical findings of this study showed remarkable variations in the multiplier values obtained from one sector to another. As opposed to this approach, the aggregate multiplier analysis of most economic base studies assumes, whether stated implicitly or explicitly, that an employment increase in <u>any</u> export industry would affect the local employment with equal intensity. This assumption may be highly untenable, since different export industries tend to exert varying degrees of employment impact on the area local employment, as borne out by findings of this study. Therefore, the disaggregation of the model to a sufficient degree may contribute to improvement of its predictive power and a better explanation of underlying basic economic relationships.

Secondly, no economic base studies, so far, seemed to have incorporated explicitly seasonal and trend adjustments in an analytical framework. The failure to allow for

seasonal adjustments may yield highly misleading empirical results especially in the short run analysis. Underlying economic conditions may fail to be revealed without proper seasonal adjustments, since short run variations in economic activities tend to be dominated by fluctuations associated with seasonal elements.

Thirdly, the incorporation into the model of a time lag between export and local employment appears to suggest substantial improvement upon the existing studies in view of significant effects of the length of lag selected on the multiplier values obtained.

Fourthly, this study would be one of the few economic base studies using time series data, if any, which attempted to test the presence of autocorrelated disturbances.

It is particularly significant to note that the aforementioned improvements made in this study accommodate Isard's following serious substantive criticisms levelled against the conceptual aspects of economic base studies:[1]

> . . . there is yet another reason why the region's over-all basic-service ratio <u>at any one time</u> is quite likely to be inaccurate as a basis for computing a multiplier value. This is a result of the fact that the change in volume of service activity associated with a change in basic activity is

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[1]Isard, <u>Methods of Regional Analysis</u>, <u>op. cit.</u>, pp. 199-203.

> typically not an instantaneous but a delayed reaction. At any given time, the overall ratio may well be influenced (distorted) by recent changes in basic activity whose multiplier effects have not yet appeared.
>
> . . . .
>
> The difficulty is that the multiplier value is an average and does not necessarily apply to any specific export activity. Industry A may import all its intermediate products, whereas Industry B may purchase all its intermediates locally. Thus the appropriate multiplier to apply to an increase in B's employment would be considerably larger than the one to apply to an identical increase in A's employment. This illustrates the limitation of applying an essentially averaging technique to situations involving only one or a few individual components of the average.

However, this study, like its predecessors, is not without limitations. The application of this study must necessarily be short run. Furthermore, for purposes of short run prediction of the area employment, the most obvious limitation is the assumption that variations in the exogenous sectors are known, so that this model permits only conditional forecasts.

Since monthly employment statistics are adequately available in almost any major metropolitan area, it would be highly useful to derive employment multipliers for several metropolitan areas comparable in size to the St. Louis SMSA, using the same technique applied to this study. The comparison of empirical results obtained from such studies would considerably shed light on interregional differences

in the economic structure in general and interregional variations in various multipliers for different sectors in particular.

The multiplier value for the aerospace industry was determined by a composite effect of NASA and Pentagon expenditures. It would be an interesting extension of this study to separate multipliers for NASA and Defense expenditures.

With an anticipated accumulation of employment statistics, it may become soon possible to construct a longer run model than that used in this study, possibly using quarterly, annual or an even longer span of employment data. The comparison of results from such a study with those of this study should prove highly fruitful.

To remedy the limitations inherent in the conditional prediction, a separate intensive analysis on the nature and behavior of each exogenous variable may be necessary.

The analytical framework adopted in this study placed primary emphasis on forces internal to a region. It was not designed to deal with forces affecting interregional trade and other complex economic relationships among several regions. At present, empirical works in this area are very scanty. It may be a fruitful research effort to undertake an empirical study of an interregional model, although the present data problem does not seem to provide

too optimistic a ground for such an attempt as yet. Such an interregional model may take the form of interregional trade multipliers which postulate functional relationships between the exports of a region and the incomes of other regions, the income of other regions and the imports of a region under consideration, and the imports of a region and its income. It is actually an application of Machlup's foreign trade multiplier to interregional trade, which incorporate explicitly feedback effects into the model. If adequate data are available, the multiregional input-output study approach suggested by Leontief and Isard[2] would represent a more rigorous formulation of complex interregional economic relationships from the theoretical viewpoint. One of the salient features of the multiregional input-output model is the disaggregation of the exports and imports of each region. Such a model delineates exports from any industry of any region to each industry in each region, and the imports of any industry of any region from each industry in each region. In short, as Leontief put it succinctly, the interregional input-output model "consists of a set of

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[2]Walter Isard, Methods of Regional Analysis, op. cit., chapter 8, pp. 309-374; Wassily Leontief and Alan Strout, "Multiregional Input-Output Analysis," Structural Interdependence and Economic Development, Proceedings of an International Conference on Input-Output Techniques, Geneva, September, 1961 (London: St. Martin's Press, 1963), pp. 119-150.

regional interindustrial input-output systems of conventional design linked together in- or rather fitted into- a separately constructed system of interregional relationships."[3]

Finally, it is hoped that current data problems on local income and expenditures would be removed in the foreseeable future so that income multipliers may be derived within an analytical framework similar to that adopted in this study. Particularly, time series data on local income by industry origin would make it possible to estimate such income multipliers.

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[3]Leontief, ibid., p. 120.

APPENDIX A

MATHEMATICAL DERIVATION OF EXPORT-LINKED EMPLOYMENT COEFFICIENTS

The mathematical derivation of indirect export employment coefficients may be necessary for clarification. First, the system of equations derived from an input-output table can be stated:

$$
\begin{array}{l}
X_1 - x_{11} - x_{12} - \cdots - x_{1n} = Y_1 \\
X_2 - x_{21} - x_{22} - \cdots - x_{2n} = Y_2 \\
\vdots \\
X_n - x_{n1} - x_{n2} - \cdots - x_{nn} = Y_n
\end{array}
\qquad (1)
$$

Here the X_i represents the total output of the "i"th industry, the x_{ij} represents the amount (in dollars or physical units) sold to the "j"th industry from the "i"th industry's product (for i, j =1, . . ., n). Therefore, the equation (1) states that goods produced (X_i) are either used as intermediate goods by producers (x_{ij}) or are directly consumed (Y_i).

Now, we define input coefficients (also called technical coefficients or constant production coefficients)

$$a_{ij} = x_{ij} / X_j$$

the amount of input of good i required per unit of output of good j, and the system of equations (1) now becomes:

$$\begin{aligned} X_1 - a_{11}X_1 - a_{12}X_2 - \cdots - a_{1n}X_n &= Y_1 \\ X_2 - a_{21}X_1 - a_{22}X_2 - \cdots - a_{2n}X_n &= Y_2 \\ \vdots \qquad \vdots \qquad \vdots \qquad & \qquad \vdots \\ X_n - a_{n1}X_1 - a_{n2}X_2 - \cdots - a_{nn}X_n &= Y_n \end{aligned} \tag{2}$$

Alternatively, the equations (2) can be expressed as

$$X_i - \sum_{j=1}^{n} a_{ij} X_j = Y_i \qquad i = 1, 2, \ldots, n. \tag{3}$$

Then, the first export-linked employment coefficients (α_i') for the "i"th industry can be derived as:

$$\alpha_i' = \sum_{j=1}^{n} \alpha_i a_{ij} \tag{4}$$

Where α_i is direct export employment coefficient for the "j"th industry.

In order to derive all indirect export employment coefficients (α_i'') which include not only the first round, but the limit value toward which successive rounds of linkages converge, the inverse matrix has to be computed. Let us state the problem in matrix form for convenience. Let A represent the matrix of given input coefficients,

X and Y the column vectors of X_i and Y_i respectively.

$$A = \begin{bmatrix} a_{11}, a_{12}, \cdots, a_{1n} \\ a_{21}, a_{22}, \cdots, a_{2n} \\ \vdots \quad \vdots \quad \vdots \\ a_{n1}, a_{n2}, \cdots, a_{nn} \end{bmatrix} \qquad X = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix} \qquad Y = \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix}$$

Then, we may state the equation (3) as

$$(I - A)\ X = Y \tag{5}$$

and

$$X = ZY \tag{6}$$

where

$$Z = (I - A)^{-1} = \begin{bmatrix} Z_{11}, Z_{12}, \cdots, Z_{1n} \\ Z_{21}, Z_{22}, \cdots, Z_{2n} \\ \vdots \quad \vdots \quad \vdots \\ Z_{n1}, Z_{n2}, \cdots, Z_{nn} \end{bmatrix}$$

The equation (6) can be expressed alternatively as:

$$X_i = \sum_{j=1}^{n} z_{ij}\ Y_i \quad i = 1, \ldots, n. \tag{7}$$

where z_{ij} is interpreted as the amount that the "i"th industry output must be expanded to meet a unit increase in the demand for good j.

Then, the indirect export employment coefficients for the "i"th industry can be stated as:

$$\alpha_i'' = \sum_{j=1}^{n} \alpha_i z_{ij} \tag{8}$$

where α_i is direct export employment coefficient for the "j"th industry.

APPENDIX B

MATHEMATICAL IDENTITY OF MODEL I WITHOUT A TIME LAG*

The mathematical identity of Model I in the absence of a time lag with $\alpha_i \neq 0.00$ or 1.00 can be shown as follows:

Model I (without a time lag): $\sum_{t=1}^{q} Y_t = \sum_{t=1}^{q} b_{ot} + b_1 \sum_{t=1}^{q} \alpha_1 X_{1t} + \ldots +$

$$b_n \sum_{t=1}^{q} \alpha_n X_{nt}$$

Where $\sum_{t=1}^{q} Y_t = \sum_{t=1}^{q}\sum_{i=1}^{n} (1-\alpha_i) X_{it}$ is the area total local employment.

When variables are expressed in deviation form around means, the column of 1's is eliminated and the equation takes the following matrix form:

$$Y = ZB$$

where

$$Y = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_q \end{bmatrix}_{q \times 1} \qquad \underline{X} = \begin{bmatrix} x_{11}, \cdots, x_{n1} \\ x_{12}, \cdots, x_{n2} \\ \vdots \qquad \vdots \\ x_{1q}, \cdots, x_{nq} \end{bmatrix}_{q \times n} \qquad B = \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_n \end{bmatrix}_{n \times 1}$$

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* The mathematical proof presented here is largely owing to the work of Dr. Edward Greenberg.

Hence,

$$Y = \begin{bmatrix} x_{11}, \cdots, x_{n1} \\ \vdots \qquad \vdots \\ x_{1g}, \cdots, x_{ng} \end{bmatrix}_{g \times n} \begin{bmatrix} 1-\alpha_1 \\ 1-\alpha_2 \\ \vdots \\ 1-\alpha_n \end{bmatrix}_{n \times 1} = \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_g \end{bmatrix}_{g \times 1} \qquad ZB = \begin{bmatrix} x_{11}, \cdots, x_{n1} \\ \vdots \qquad \vdots \\ x_{1g}, \cdots, x_{ng} \end{bmatrix}_{g \times n} \begin{bmatrix} \alpha_1 & & & 0 \\ & \alpha_2 & & \\ & & \ddots & \\ 0 & & & \alpha_n \end{bmatrix} \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_n \end{bmatrix}_{n \times 1}$$

Least squares estimators can be derived from the regression equation,

$$Y = Z\hat{B} + e$$

where the equation is expressed in matrix notation, and e is the column vector of n residuals ($Y - Z\hat{B}$). Then

$$\sum_{i=1}^{n} e_i^2 = e'e = (Y - Z\hat{B})' (Y - Z\hat{B}) = Y'Y - 2\hat{B}'Z'Y + \hat{B}'Z'Z\hat{B}$$

To find the value of $\hat{B}$ which minimizes the sum of squared residuals, the above equation is differentiated with respect to $\hat{B}$

$$\frac{\partial}{\partial \hat{B}} (e'e) = -2Z'Y + 2Z'Z\hat{B}$$

Equating to zero gives

$$Z'Z\hat{B} = Z'Y, \text{ therefore, } \hat{B} = (Z'Z)^{-1} Z'Y.$$ [1]

Let $X = \begin{bmatrix} x_{11}, \cdots, x_{n1} \\ \vdots \qquad \vdots \\ x_{1g}, \cdots, x_{ng} \end{bmatrix}_{g \times n}$ $P = \begin{bmatrix} \alpha_1 & & & 0 \\ & \alpha_2 & & \\ & & \ddots & \\ 0 & & & \alpha_n \end{bmatrix}_{n \times n}$ $M = \begin{bmatrix} 1-\alpha_1 \\ 1-\alpha_2 \\ \vdots \\ 1-\alpha_n \end{bmatrix}_{n \times 1}$

then $Z = XP$, $\quad Y = XM$

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[1] See J. Johnston, Econometric Methods, (New York: McGraw-Hill, 1960), pp. 108-109.

$$\hat{\beta} = (\mathbf{Z}'\mathbf{Z})^{-1}\mathbf{Z}'Y = \left[(\mathbf{X}P)'(\mathbf{X}P)\right]^{-1}(\mathbf{X}P)'(\mathbf{X}M) = \left[P'\mathbf{X}'\mathbf{X}P\right]^{-1}P'\mathbf{X}'\mathbf{X}M$$

$$= P^{-1}M = \begin{bmatrix} \frac{1}{\alpha_1} & & \bigcirc \\ & \frac{1}{\alpha_2} & \\ & & \ddots & \\ \bigcirc & & & \frac{1}{\alpha_n} \end{bmatrix}_{n\times n} \begin{bmatrix} 1-\alpha_1 \\ 1-\alpha_2 \\ \vdots \\ 1-\alpha_n \end{bmatrix}_{n\times 1} = \begin{bmatrix} \frac{1-\alpha_1}{\alpha_1} \\ \frac{1-\alpha_2}{\alpha_2} \\ \vdots \\ \frac{1-\alpha_n}{\alpha_n} \end{bmatrix}_{n\times 1} = \begin{bmatrix} b_1 \\ b_2 \\ \vdots \\ b_n \end{bmatrix}_{n\times 1}$$

therefore,

$$b_1 = \frac{1-\alpha_1}{\alpha_1}, \quad b_2 = \frac{1-\alpha_2}{\alpha_2}, \quad , \quad , \quad b_n = \frac{1-\alpha_n}{\alpha_n}$$

$$b_o = \bar{Y} - b_1\bar{X}_1 - b_2\,X_2 - \cdots - b_n\bar{X}_n$$

$$= \left[(1-\alpha_1)\;\bar{X}_1 + (1-\alpha_2)\;\bar{X}_2 + \cdots + (1-\alpha_n)\;\bar{X}_n\right]$$

$$- \left[\frac{1-\alpha_1}{\alpha_1}\alpha_1\bar{X}_1 + \frac{1-\alpha_2}{\alpha_2}\alpha_2\bar{X}_2 + \cdots + \frac{1-\alpha_n}{\alpha_n}\alpha_n\bar{X}_n\right] = 0$$

APPENDIX C

THE BUREAU OF LABOR STATISTICS EMPLOYMENT ESTIMATION METHOD

The employment estimates for the St. Louis SMSA are prepared monthly by the Missouri Division of Employment Security as a part of an integrated Federal-State program, sponsored by the Bureau of Labor Statistics in cooperation with the Bureau of Employment Security, U. S. Department of Labor.[1]

The employment statistics cover estimates of wage and salaried non-farm employment but excludes proprietors, the self-employed, unpaid family workers, farm workers, and domestic workers in households. Government employment covers only civilian employees and excludes federal military personnel. Industry employment estimates are collected on the establishment basis and they refer to persons on the establishment payrolls who received pay for any part of the pay period ending nearest the 15th of the month.

The industrial classification of establishments

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[1]For a comprehensive account of the BLS employment estimation method, see the technical note of BLS on measuring employment, hours, and earnings in states and areas, Employment and Earnings Statistics for States and Areas 1939-62, Bureau of Labor Statistics (Washington: U. S. Government Printing Office, 1963), pp. 629-633.

was made in accordance with the 1957 SIC manual on the basis of their primary product or activity as determined from information on their annual sales volumes. In case of a multi-products establishment, the most important product or activity determines the industrial classification of such an establishment.

Employment estimating methods are characterized by three main features: (1) the use of the "link relative" technique, which is a form of ratio estimation; (2) periodic adjustments of employment levels to new benchmarks; (3) the use of a modified cutoff type sample. All the terms will be defined later when each technique is discussed.

Form BLS 790 (confidential report on employment, payrolls, and hours), called shuttle schedules, is used to collect employment, payroll, and man-hours data. The schedule, with space for each month of the calendar year is returned to reporting establishments every month so that the next month's data can be entered. This procedure is followed to ensure the maximum comparability and accuracy of reporting in relation to the past data.

From a sample of establishments, which reported through the shuttle schedule for both the current and previous months, the ratio of current month employment to that of previous month is computed. Then, the employment

estimates for the previous month are multiplied by the ratio, called "link relatives" in order to obtain the current employment estimates. At the aggregate industry level, employment is the sum of the employment estimates for component industries.

The monthly estimates obtained from cooperating establishments are compared annually with comprehensive counts of employment, which provide "benchmarks" for various industries. The principal source of benchmark information is the employment data by industry, compiled quarterly by state employment security agencies under state unemployment insurance laws. About three-fourths of the total non-agricultural employment in the United States are included in these reports. The remaining benchmark data are supplemented from various sources such as the records of the Social Security Administration, the Interstate Commerce Commission, and other agencies in private industry or government.

A cutoff sample design is used in the collection of employment estimates. In a cutoff design, all establishments are arranged in a descending order in terms of the number of employees. A cutoff point is selected in such a way that establishments included in the sample, those above the cutoff point, comprise a sufficiently large proportion of universe employment to warrant satisfactory

estimates. Emphasis is placed not only on a heavy representation of the largest establishments in each industry, but on the inclusion of a sufficient number of small establishments.

Since the BLS employment estimates are not based on a probability sample, statistical error formula, usually in the form of standard error of estimates, cannot be derived to test the reliability of such estimates. However, the BLS uses different criteria for testing the reliability of estimates. Employment estimates projected from a benchmark are compared with the amount estimated from the new benchmark at the next adjustment period. The difference between them indicates the probable magnitude of reliability.

A high degree of reliability of estimates is maintained by the inclusion of a large segment of universe in the sample, supplemented by annual adjustments of estimates to benchmark levels. Differences between the benchmarks and the estimates arise from (1) sampling and response errors, (2) changes in the industrial classification of individual establishments, and (3) improvement in the quality of benchmark data. At broader aggregations of industries, the second discrepancy becomes less important.

The employment data for the St. Louis SMSA used for this study were adjusted to 1963 benchmarks. The breakdown of the number of establishments and employees included in the sample is as follows:[2]

	Number of Establishment	Number of Employees	% of total
Manufacturing	679	202,671	78.1% of total manufacturing
Non-Manufacturing	1137	147,903	31.5% of total non-manufacturing
Mining			47.9%
Construction			25.6
Trucking			29.2
Public Utility			77.1
Wholesale			23.2
Retail			21.8
Finance, Insurance, and Real Estate			36.0
Services			22.5
Governments			54.9
Railroad (obtained from BLS)			
Total Non-Agricultural	1816		48.1

[2]This information was obtained directly from Mrs. Mildred Helmholt, Research Analyst, Missouri Division of Employment Security, St. Louis, Mo.

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Abstract

AN ANALYSIS OF REGRESSION ESTIMATES FOR URBAN EMPLOYMENT MULTIPLIERS AND THEIR APPLICATION TO THE EMPLOYMENT IMPACT OF THE AEROSPACE INDUSTRY IN THE ST. LOUIS SMSA

by Se-Hark Park

Chairman: Professor Edward Greenberg

The primary purpose of this study was to estimate, through multiple regression and correlation, differential employment impacts on the St. Louis Metropolitan Area Economy resulting from monthly variations in the activity levels of major export industries and the area investment sector during the period of January 1958 to June 1964.

The area economic activities were classified as either exogenous or endogenous, depending upon whether the levels of operation of particular activities are explained by the model or not. Exports, the area invest ment sector, net factor payments and net transfer payments to the area were treated as major exogenous variables, and the activities of most locally oriented consumption and service industries as endogenous.

Various employment multiplier estimating equations, both aggregate and disaggregate types, were developed to test the employment multiplier hypothesis which postulates the explanatory dependence relationship between the exogenous and endogenous employment, and further asserts a multiplier value of greater than one.

Monthly employment data by industry from January 1958 to June 1964 were collected and classified into exogenous and endogenous employment by industry. Then, the data were fitted to multiple regression and correlation for the statistical estimation of the model. A three month

time lag between exogenous and endogenous employment yielded the best empirical fit out of the six different time lags experimented with, and was incorporated into all the employment multiplier estimating equations.

The empirical results indicated the presence of highly significant relationships between exogenous and endogenous employment, and verified the theoretical hypothesis of an employment multiplier value of greater than one. The relative strength of employment impacts on the area economy varied substantially from one sector to another, mainly due to the interindustry differences in the income-induced and interindustry effects. The introduction of trend and dummy variables for seasonal adjustments into the equations improved considerably the regression fits. The Durbin-Watson d statistic test was conducted to test the presence of autocorrelation. The test was inconclusive at five and one percent significance levels.

The multiplier effects of the aerospace industry in St. Louis appeared to work largely through the income-induced effects the relative strength of the interindustry effects seemed to be insignificant.